Wadi Alshatti University Journal of Pure and Applied Sciences

مجلة جامعة وادي الشاطئ للعلوم البحتة والتطبيقية

Volume 4, No. 2, July-December 2026 Online ISSN: 3006-0877 المجلد 4، الاصدار 2، يوليو- ديسمبر 2026

RESEARCH ARTICLE **MEDICAL MICROBIOLOGY**

Assessment of Bacterial Contamination on Non-Living Surfaces and Equipment at Sabratha Teaching Hospital

Halemah Mohamed Alashoury[1,*], Khalid Othman[2], Abulkasim Mohamed Abulkasim[3]

[1] Department of Medical Laboratory Sciences, Faculty of Medical Technology, Wadi Alshatti University, Libya

[2] Department of Infection Control, Sabratha Teaching Hospital, Sabratha, Libya

[3] Faculty of medicine, University of Tripoli, Libya

ARTICLE HISTORY

Received 21 September 2026
Revised 19 October 2026
Accepted 30 October 2026
Online 04 November 2026

KEYWORDS

Hospital Acquired Infection;
Infection;
Immunocompromised;
Intensive care unit;
Klebsiella;
Pseudomonas aeruginosa.

ABSTRACT

Due to their high rates of morbidity and mortality, hospital-acquired infections (HAIs) are a major worldwide health concern. Bacterial contamination of hospital surfaces and equipment has been recognized as a major means for nosocomial infection spread worldwide. The extent of contamination on surfaces and equipment in the various departments of Sabratha Teaching Hospital remains poorly understood, despite its importance. The purpose of this study is to evaluate the rate of bacterial contamination at Sabratha Teaching Hospital on inanimate surfaces and equipment, as well as its susceptibility to antibiotics. **Methodology:** From July to October 2025, a descriptive cross-sectional investigation was carried out in various hospital wards. The Sabratha Teaching Hospital served as the study's site. For this study, 70 swabs samples were taken from high-contact surfaces for inanimate surfaces and equipment including Emergency department, newborn intensive care unit, Orthopedics and orthopedic surgery department, Hemodialysis unit, obstetrics and Gynecology department, children s department, Intensive care unit, were grown on general media selective media, and enriched media, such as MacConkey agar and blood agar, in order to determine the types of bacteria found. The data was entered and analyzed using descriptive statistics. **Results:** Thirty-two samples (45.7%) showed bacterial growth. Gram-negative bacteria were the most prevalent among the identified bacteria, with *Klebsiella spp* being the most common, accounting for 12 samples (37.5%), followed by *Pseudomonas aeruginosa* with 8 samples (25%). As for Gram-positive samples, they were of the species *Staphylococcus epidermidis*, accounting for 12 samples (37.5%). **Conclusion:** Surfaces and equipment in various wards may contain a variety of harmful germs that could infect patients, particularly those who are critically ill or immunocompromised. Evaluating infection control procedures, putting in place routine disinfection programs, and educating medical personnel about the possibility of pathogen transfer from hospital surfaces and equipment are all essential to reducing this risk.

تقييم التلوث البكتيري للأسطح والمعدات غير الحية في مستشفى صبراتة التعليمي

حليمة محمد العاشوري[1,*]، خالد عثمان[2]، أبوالقاسم محمد ابوالقاسم[3]

الكلمات المفتاحية

العدوى المكتسبة من المستشفيات
العدوى
ضعف الجهاز المناعي
وحدة العناية المركزة
الكليبسيلا
سيدوموناس/ايريوجينوسا.

الملخص

تعد العدوى المكتسبة في المستشفيات مصدر قلق صحي كبير على الصعيد العالمي، وذلك بسبب ارتفاع معدلات الإصابة بها والوفيات الناجمة عنها. وقد تم الاعتراف بأن التلوث البكتيري لأسطح ومعدات المستشفيات يُعد أحد الأسباب الرئيسية لانتشار العدوى المكتسبة في المستشفيات في جميع أنحاء العالم. ولا يزال مستوى تلوث الأسطح والمعدات في الأقسام المختلفة بمستشفى صبراتة التعليمي غير مفهوم جيدًا، على الرغم من أهميته. تهدف هذه الدراسة إلى تحديد نسبة التلوث البكتيري للأسطح والمعدات غير الحية، ومدى حساسيتها للمضادات الحيوية في مستشفى صبراتة التعليمي. **المنهجية:** أُجريت دراسة وصفية مستعرضة في عدة أجنحة بالمستشفى خلال الفترة من يوليو إلى أكتوبر من عام 2025. وكان مستشفى صبراتة التعليمي هو موقع الدراسة. حيث تم اخذ 70 مسحة من الأسطح غير الحية والمعدات من الأقسام المختلفة بالمستشفى والتي تشمل قسم حديثي الولادة، وقسم جراحة العظام وقسم غسيل الطلى وقسم النساء والولادة وقسم الأطفال ووحدة العناية الفائقة من أجل تحديد أنواع البكتيريا المكتشفة، وزُرعت على أوساط عامة وأوساط تمييزية وأوساط مُغَنَّاة، مثل وسط ماكونكي ووسط اجار الدم. واستُخدمت الإحصاءات الوصفية لإدخال البيانات وتحليلها. **النتائج:** كانت نتائج 32 عينة (45.7%) إيجابية لنمو البكتيريا. وكانت البكتيريا سالبة الجرام هي الكليبسيلا الأكثر انتشارا بين البكتيريا التي تم تحديدها والتي كانت 12 عينة بنسبة (37.5%)، تلها بكتيريا سيدوموناس ايريوجينوسا 8 عينات بنسبة (25%)، أما العينات موجبة الجرام فكانت من نوع المكورات العنقودية الجلدية 12 عينة بنسبة

*Corresponding author
https://doi.org/10.63318/waujpasv4i2_67
This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License (CC BY-NC 4.0).

(37.5%). **الخلاصة**: قد تحتوي الأسطح والمعدات في مختلف الأقسام على مجموعة متنوعة من الجراثيم الضارة التي قد تصيب المرضى، لا سيما أولئك الذين يعانون من حالات حرجة أو يعانون من ضعف في جهاز المناعة. ويُعد تقييم إجراءات مكافحة العدوى، ووضع برامج تطهير روتينية، وتوعية الطاقم الطبي باحتمال انتقال مسببات الأمراض من أسطح المستشفى ومعداته، أمورًا أساسية للحد من هذا الخطر.

Introduction

The word "bacterial contamination" refers to biological contamination, which is the spread of bacteria by physical (sharing media and chemicals using unsterilized pipettes and handling inanimate objects improperly) and biological (direct or indirect contact with the hands) [1]. Medical charts, computer keyboards, cell phones, and equipment used for direct patient treatment, such as stethoscopes and ultrasound machines, may be contaminated with bacteria [2]. There is mounting evidence that diseases linked to healthcare can spread through contaminated inanimate surfaces, particularly those that are often touched with bare hands [3].

The impact of bacterial contamination on operating rooms and hospital care and its overall impact on hospital infection control is important for the patient and the healthcare team [4,5,6].

Different prevalence rates of Hospital Acquired Infections (HAIs) have been documented by numerous research carried out globally. The majority of these investigations found that the most common bacteria linked to HAIs and antibiotic resistance were *Escherichia coli*, *Staphylococcus aureus*, *Klebsiella species, and coagulase-negative staphylococci* [7,8,9,10].

personnel play in the spread of bacterial diseases to patients; germs can spread straight from contaminated surfaces to patients who are vulnerable [11, 12].

The experimental side of the story developed mostly A research carried out at a hospital in Baghdad found that most medical staff members are the primary polluters because they regularly go between operating rooms and other parts of hospital wards without changing their gowns and shoes [13]. According to a comprehensive analysis, more than half of bacterial infections following clean surgery are caused by opportunistic pathogens linked to staff members' skin, which are the primary source of surface pollutants during operating procedures [14].

Employee negligence and excessive keyboard contact caused contamination, which is the source of HAIs [15]. Children are particularly susceptible to HAIs because of their weakened immune systems. Antibiotic resistance, patient morbidity, and death are among the consequences that result from hospitals' poor hygiene practices and improper patient treatment [16].

Nonetheless, some investigations have discovered indications of contamination of certain commonly used hospital ward equipment. Gram positive pathogens like *Staphylococcus aureus*, Vancomycin Resistant *Enterococci* (VRE), Coagulase negative staphylococcus, and Methicillin Resistant Staphylococcus aureus were more frequently detected than gram negative pathogens like *Pseudomonas aeruginosa*, non-fermenting gram-negative bacteria, *Acinetobacter baumannii*, and *Klebsiella species* [17, 18, 19].

Gram-negative bacterial infections are still a major problem in healthcare settings, especially in teaching institutions where patient care demands and infection complexity are frequently greater [20]. Because of their tenacity and capacity to develop antibiotic resistance, gram-negative bacteria represent a serious risk to public health and patient outcomes. [21]. Since Gram-negative bacteria are frequently linked to serious, potentially fatal illnesses such sepsis, pneumonia, urinary tract infections, and surgical site infections, the rising prevalence of these infections in Libya has sparked worries.

Gram negative bacteria remain a major cause of hospital-acquired infections (HAIs) in teaching hospitals, where specialist care and sophisticated diagnostic equipment are easily accessible [22]. Antimicrobial resistance (AMR) is made worse by things like overcrowded wards, poor infection control procedures, and antibiotic abuse. Gram negative bacteria's resistance, especially to important antibiotics like aminoglycosides, cephalosporins, and carbapenems, has reduced treatment options, leading to longer hospital stays, higher healthcare expenses, and higher death rate [23].

Moreover, microbial contamination on non- living surfaces and equipment can lead to outbreaks of infections within healthcare facilities, compromising the safety of both patients and staff. Reducing microbial contamination through improved hand hygiene practices is critical for minimizing the occurrence of HAIs and improving patient outcomes, then depending on the above lines this study aim to evaluate the rate of bacterial contamination at Sabratha Teaching Hospital on inanimate surfaces and equipment, as well as its the effectiveness of the most commonly used antibiotics.

Materials and Methods

Study design and setting

The Sabratha Teaching Hospital in Sabratha City, Libya's emergency room, newborn intensive care unit (NICU), orthopedics department, orthopedic surgery department, hemodialysis unit, obstetrics and gynecology department, children's department, and intensive care unit were the sites of this cross-sectional study, which took place between July and October of 2025.

For this study, 9 swab samples were taken from high-contact surfaces in Emergency department, including [betadine, sodium chloride bottle, medicine cart, nurses, needles, boxes, tongue depressant, thermometer], 22 swab samples were taken from newborn intensive care unit which were taken from [Cannula entrance, baby pillow, incubator water, cotton box, needle, heater, the scale, laryngoscope, betadine, vein detector, nasal mask, upper washbasin, washbasin opening, incubator water, incubator, oxygen bowl], 18 swab from orthopedics and orthopedic surgery which were taken from [examination room, soap, betadine bottle, refrigerator, alcohol bottle, department door, BCG device, medical trolley, and male, female examination bed], 11 swab from hemodialysis unit which were taken from [Nacl Hall 2, incubator, green liquid soap, instruments Hall 2, purified water for hemodialysis, from hand of nurses, artificial respirator] and , 5 swab were taken from obstetrics and Gynecology department which were from [operating table, baby coat, anesthesia machine, operating section], 3 swab from children s department which were taken from [children s examination table, ground, and vein finder], 2 swab from Intensive care unit which taken from [washbasin surface and artificial respirator].

The samples were taken over four months, in July and October of 2025. To ensure accuracy, particular attention was paid to hand decontamination and the use of gloves before sample collection, as well as maintaining a sterile environment during the process. After collection, samples were immediately transported to the microbiology lab. A sterile cotton swab, moistened with Trypticase Soy Broth (TSB) medium, was used to swab the non-living surfaces and the equipment's from different department of hospital. Each swab was sealed, labeled with a sample number, and incubated for 24 hours at 37°C. After incubation, samples were cultured on various nutrient media, including blood agar and MacConkey agar and incubated again for 24 hours at 37°C to differentiate and identify microbial types [24, 25].

The blood agar plates were checked to identify the type of microorganisms present, and a catalase test was performed to differentiate between *Staphylococcus* and *Streptococcus* species. MacConkey agar plates were examined for the presence of Gram-negative bacilli. For organisms in the *Enterobacteriaceae* family, carbohydrate fermentation was assessed using Triple Sugar Iron (TSI) agar, along with biochemical tests such as Sulfide Indole Motility (SIM), Simmons' Citrate, and Christensen's Urea agar to further identify the microbes [26, 27]. Oxidase tests was carried out to identify glucose-non-fermenting Gram-negative bacteria. Additional biochemical tests using API-20E kits were performed for further identification of organisms. Finally, antimicrobial susceptibility testing was conducted on Muller Hinton agar plates by adjusting the bacterial suspension to the 0.5 McFarland standard.

Sample collection

Microbial samples were collected from the non- living surfaces and equipment's. The method of sample collection involved swabbing the surfaces using sterile cotton swabs. These swabs were then immediately placed into transport media to preserve any microorganisms present. The swabs were taken to the laboratory within an hour of collection to ensure the viability of the microorganisms. In the lab, the swabs were infected onto nutrient agar and stored at 37°C for 48 hours. Blood agar plates were purified by aerobic 24-hour incubation at 37 °C, and MacConkey agar was utilized for subculture.

Identifying Isolated Bacteria

To distinguish between Gram-positive and Gram-negative bacterial isolates, standard microbiological techniques like colony morphology and Gram stain are employed. To identify all pure isolates, thorough biochemical analyzes utilizing oxidase, catalase, and coagulase were carried out [28].

Biochemical Tests

Test for catalase

The catalase enzyme catalyzes the conversion of hydrogen peroxide to oxygen water. This test involves adding two to three milliliters of 3% hydrogen peroxide to a test tube in order to distinguish between staphylococci and streptococci. The tested organism's good growth is removed using a sterile wooden stick, which is then submerged in the hydrogen peroxide solution. Positive results are shown by immediate aggressive bubbling [29, 30].

Test for coagulase:

When bacteria are cultured with plasma, an enzyme called coagulase converts fibrinogen to fibrin, causing plasma to clot. This test is used to distinguish between coagulase-positive and coagulase-negative staphylococci. A colony of the tested organism was combined with a drop of normal saline on each end of a slide to create a thick suspension. A loopful of plasma was then added to the suspension and gently mixed. Clumping of positive results in less than ten seconds [30].

API-20E Kit Analysis and Antimicrobial Susceptibility

Further confirmation and identification of Gram-negative bacteria were achieved using API-20E biochemical test kits, which provided additional species-level identification for members of the *Enterobacteriaceae* family. The isolates of *Klebsiella pneumoniae* was conclusively identified. Finally, antimicrobial susceptibility testing was performed on all isolated organisms using the Muller Hinton agar. Modified Kirby-Bauer disk diffusion is used for antibiotic susceptibility testing after isolation and identification, according to a Clinical and Laboratory Standards Institute (CLSI) guideline [31]. Muller Hinton Agar (MHA) is the typical medium used in the Kirby-Bauer method of susceptibility testing. The bacterial suspension was made by mixing one drop of sterile normal saline with one pure colony of bacteria. The concentration of the bacteria was then determined by comparing the bacterial suspension to the 0.5 McFarland standard [32, 33].

The entire MHA plate was covered with a swab of the test organism suspension. Allow the items to air dry completely after three 360-degree rotations of the platter. After the antibiotic pills were added to the contaminated plates using tongs, the dishes were incubated at 37°C for a whole day. Using the supplied ruler, inhibitory areas surrounding each antibiotic tablet were also measured in order to assess the isolates' susceptibility to various antibiotics. Microbes were growing around the disk in some parts, suggesting that there was no zone surrounding it and that the antibacterial chemical was inert, while other areas exhibited no microbial growth, indicating that the antibacterial agent is effective.

In this study, antibiotic disks used were Augmentin (Amc), Cefotaxime (CTX), Ceftriaxone (CRO), Ceftazidime (CAZ), Cefuroxime (CXM), Cefixime (CFM), Meropenem (MEM), Imipenem (IPM), Cefoxitin (FOX), Amikacin (AK), Ceftricillin (CTR), Vancomycin, Linezolid (LNZ), Polymyxin, Ciprofloxacin (CIP), Cotrimoxazole (COT), manufactured by the Bioanalyses company.

Analysis of Data

Descriptive statistics were used to assess data obtained from antimicrobial susceptibility tests and bacterial identification. The resistance profiles and prevalence of various Gram-negative organisms were computed. For the distribution of microorganisms, the data were displayed as percentages and frequencies.

Results

Screening of bacterial contamination in Sabratha Teaching Hospital

The sample collection process was restricted to a limited period of time due to the conditions of the hospital was going through; therefore, the duration of samples collection was performed within 4 months, that represented total of samples was 70.

The investigation of the bacterial contamination into the different hospital facilities included 70 samples. The results obtained from obstetrics and Gynecology department showed (80%) of microbial contamination, however, emergency department thermometer showed less frequent of microbial contamination (33%) Table 1.

Table 1: Locations of bacterial isolate from the hospital environment at Sabratha teaching hospital

Department	Growth n(%)	No Growth n(%)	Total N
emergency department	3(33)	6(66.6)	9
newborn intensive care unit	11(50)	11(50)	22
Orthopedics and orthopedic surgery	7(38.8)	11(61)	18
Hemodialysis unit	4(36.4)	7(63.6)	11
obstetrics and Gynecology department	4(80)	1(20)	5
children department	2(66.6)	1(33.3)	3
Intensive care unit	1(50)	1(50)	2
Total	32(45.7)	38(54.2)	70

Type of Bacterial isolates in hospital wards at Sabratha teaching hospital

The bacterial distribution that contaminates the hospital facilities showed contamination with *S. epidermidis* and *Klebsiella spp* which considered the most predominant microbe isolated from the different hospital wards followed by *Pseudomonas aeruginosa*. Out of the 70 swabs that were examined for the presence or absence of bacteria after 48 hours of incubation, 32 samples (45.7%) showed signs of growth, while the remaining 38 samples (54.3%) did not. Furthermore, the results showed that 12 samples (35.7%) had Gram-positive bacteria and 20 samples (62.5%) had Gram-negative bacteria. *Staphylococcus epidermidis* 12 (35.7%) was the possible Gram-positive bacterium that was isolated. According to Tables 2, *Pseudomonas aeruginosa* 8 (25%) and Klebsiella spp. 12 (35.7%) were the possible Gram-negative organisms that were isolated.

Table 2: types and frequency of bacteria found on inanimate surfaces in various Sabratha Teaching Hospital wards.

Types of isolates	Gram-Positive & Negative N	Percentage (%)
Staphylococcus epidermidis	12	35.7
Klebsiella spp	12	35.7
Pseudomonas aeruginosa	8	25

Antimicrobial susceptibility testing

Antimicrobial resistance was performed based on the data supplied by the diffusion disc manufacturer. All antimicrobial was the effective antimicrobial for the treatment of *S. epidermidis* isolates and had intermediate resistance to ceftricillin as showed in Table 3.

The bacterium (*Klebsiella spp*.) was susceptible to every antibiotic, with the exception of Augmentin and Cefuroxime, as indicated in Table 4, despite the isolates being insufficient to offer a significant antimicrobial sensitivity.

Table 3: Staphylococcus epidermidis profile of antibiotic Sensitivity

Organism	Antimicrobial	Total tested	Sensitive n(%)	Intermediate n(%)	Resistance n(%)
Staphylococcus epidermidis	Ceftricillin	12	0(0%)	12(100%)	0(0%)
	Vancomycin	12	12(100%)	0(0%)	0(0%)
	Linezolid	12	12(100%)	0(0%)	0(0%)
	Polymyxin	12	12(100%)	0(0%)	0(0%)
	Ciprofloxacin	12	12(100%)	0(0%)	0(0%)
	Cefotaxime	12	12(100%)	0(0%)	0(0%)
	Cotrimoxazole	12	12(100%)	0(0%)	0(0%)

Table 4: The *Klebsiella species'* profile of antibiotic sensitivity

Organism	Antimicrobial	Total tested	Sensitive n(%)	Intermediate n(%)	Resistance n(%)
Klebsiella spp	Augmentin	12	0(0%)	0(0%)	12(100%)
	Cefotaxime	12	12(100%)	0(0%)	0(0%)
	Ceftazidime	12	12(100%)	0(0%)	0(0%)
	Cefuroxime	12	0(0%)	0(0%)	12(100%)
	Cefixime	12	12(100%)	0(0%)	0(0%)
	Cefoxitin	12	12(100%)	0(0%)	0(0%)
	Meropenem	12	12(100%)	0(0%)	0(0%)
	Imipenem	12	12(100%)	0(0%)	0(0%)
	Amikacin	12	12(100%)	0(0%)	0(0%)

Pseudomonas aeruginosa shown a high level of resistance to every antibiotic, including Augmentin (100%), Cefotaxime (100%), Ceftriaxone (100%), Cefuroxime (100%), Cefixime (100%), and Meropenem (100%). Imipenem showed 100% sensitivity against *P. aeruginosa*, as Table 5 illustrates.

Discussion

Approximately 45.7% of the 70 environmental swabs of inanimate surfaces and equipment that were examined were contaminated with bacteria, which presents a significant risk of nosocomial infections, as has also been noted in recent investigations conducted in East Africa and elsewhere [34, 35]. According to surveillance studies conducted throughout sub-Saharan Africa, this high contamination incidence may be the result of poor adherence to Infection Prevention and Control (IPC) measures [36, 37].

The investigation's findings indicate a bacterial contamination rate of 70 cases (45.7%), which is in line with the 44.2% reported from Uganda's Kawolo General Hospital [38], and 25.6% from the referral hospitals in Assiut City, Egypt [39]. This incidence, however, is less than the 76% recorded at the Kishan University of Medical Science and Health Hospital in Iran [15], the 86.6% at Northern Tanzania Zonal Referral Hospital and the 66.7% in pediatric wards 35 in Nigerian hospitals [40]. This may be but not sure can be the result of inadequate disinfection and hand hygiene practices.

Table 5: *Pseudomonas aeruginosa* profile of antibiotic sensitivity

Organism	Antimicrobial	Total tested	Sensitive n(%)	Intermediate n(%)	Resistance n(%)
Pseudomonas aeruginosa	Augmentin	8	0(0%)	0(0%)	8(100%)
	Cefotaxime	8	0(0%)	0(0%)	8(100%)
	Ceftriaxone	8	0(0%)	0(0%)	8(100%)
	Cefuroxime	8	0(0%)	0(0%)	8(100%)
	Ceftazidime	8	0(0%)	0(0%)	8(100%)
	Cefixime	8	0(0%)	0(0%)	8(100%)
	Meropenem	8	0(0%)	0(0%)	8(100%)
	Imipenem	8	8(100%)	0(0%)	0(0%)

The most common bacteria in this work were *S. epidermidis* and *Klebsiella spp.* isolates, followed by *Pseudomonas aeruginosa*. These findings are consistent with a different study carried out at the Sirte Teaching Hospital in Libya [41]. These bacteria may be more common because of their broad adaptability, which allows them to flourish in a variety of settings and clinics [42].

Hospitalized patients are at greater risk since these organisms have a strong ability to build biofilms on clinical surfaces and withstand the actions of antibiotics and disinfectants.

Vulnerable pediatric patients are at serious danger from *Staphylococcus epidermidis* and *Klebsiella spp.* Inadequate surface decontamination practices are highlighted by *P. aeruginosa*, a waterborne bacterium that flourishes in damp settings like sinks and unsanitized medical equipment. Growing antimicrobial resistance increases the risk of serious infections, and many of these organisms are becoming common clinical isolates linked to nosocomial infections that are resistant to several drugs [43].

Compared to the 20.8% prevalence reported in the Sirte teaching hospital in Libya, a strikingly high percentage of *Klebsiella spp*. (35.7%) was found [41].

On the other hand, the proportion of *Pseudomonas aeruginosa* was relatively low in this study at 8 (25%), and in Northern Tanzania Zonal Referral Hospital compared to 31.3% in Sirt, Libya and 1.3% in Nigerian Hospitals [44].

Antimicrobial resistance, which causes around 700,000 deaths a year and is predicted to cause about 10 million deaths by 2050, is still one of the biggest dangers to world health [38]. *Staphylococcus epidermidis* showed susceptibility to the majority of the antimicrobials utilized in this investigation. Nonetheless, resistance to Augmentin, Cefuroxime, Cefotaxime, Ceftriaxone, Ceftazidime, Cefixime, and Meropenem was found in Gram-negative bacteria.

This may be related to the increasing overuse and abuse of antibiotics by the general public, which is exacerbated by a lax healthcare management system that permits access to medications without the required prescriptions.

A major barrier to infection management and treatment results is the existence of resistant organisms like *Pseudomonas aeruginosa* and *Klebsiella spp*. These results are in line with research done at the Sirt Hospital in Libya. highlighting the critical need for efficient antimicrobial stewardship initiatives, regular monitoring of resistance trends, and the enhancement of infection control procedures in healthcare environments.

Research on the presence of Gram-negative bacteria (GNB) in environmental samples is essential for understanding the spread of illnesses, antimicrobial resistance (AMR), and implementing effective infection control techniques [45]. This is an important field of study since Libya, like other nations in the region, suffers difficulties with healthcare infrastructure and rising AMR. Gram-negative bacteria, such as *Pseudomonas aeruginosa* and *Klebsiella pneumonia*, are the main cause of hospital-acquired infections (HAIs) [46].

These bacteria can live in hospital environments (such as water and surfaces) and the wider environment (such as wastewater) as reservoirs for resistant strains [47]. Resistant GNB can enter the community through environmental reservoirs like hospital effluent [48].

Significant risks of bloodstream infections, urinary tract infections (UTIs), and surgical site infections are indicated by the presence of these bacteria in clinical samples (such as blood, urine, and wounds) [49]. The results align with research conducted in other Middle Eastern and North African (MENA) nations, where environmental pollution and GNB related to healthcare are common. However, compared to nearby nations, Libya's particular sociopolitical issues—such as its lack of infrastructure and resources for infection control—may make the issue worse [50].

Conclusion

The study's findings demonstrated a substantial burden of bacterial contamination and antibiotic resistance across multiple wards at Sabratha Teaching Hospital, underscoring the urgent need for targeted treatments to reduce nosocomial infections and enhance patient safety. Our results show that a medium proportion of pathogenic bacteria, including *P. aeruginosa* and *Klebsiella species*, are the primary contaminants. This implies that one of the main causes of hospital-acquired infections (HAIs) is probably bacterial contamination of surfaces and equipment. Surfaces and equipment in various hospital wards may contain microorganisms that put critically ill or immunocompromised patients at significant risk. Apply studies in future by use large number of sample, evaluating infection prevention techniques, putting regular disinfection procedures into place, and educating medical staff about the possibility of pathogen transfer from hospital surfaces and equipment are all crucial to reducing this risk.

Author Contributions: "**Othman, Abulkasim**: Conceptualization, methodology; **Alashoury**: writing—original draft preparation, review and editing. All authors have read and agreed to the published version of the manuscript."

Conflicts of Interest: "The authors declare no conflict of interest."

Funding: "This research received no external funding."

Data Availability Statement: "The data are available from the corresponding author upon request".

Acknowledgments: Deep thanks to the department of Infection control at Sabratha Teaching Hospital, especially its Director, Mr. Khalid Othman, and all the staff for their kind cooperation".

References

[1] E. Abatenh, B. Gizaw, and Z. Tsegaye. "Contamination in a Microbiological Laboratory." *International Journal of Research Studies in Biosciences*, vol. 6, no. 4, pp. 7-13, 2018. https://doi.org/10.20431/2349-0365.0604002

[2] V. Russotto, A. Cortegiani, S. Raineri, and A. Giarratano. "Bacterial contamination of inanimate surfaces and equipment in the intensive care unit." *Journal of Intensive Care*, vol. 10, no. 3, pp. 54, 2015. https://doi.org/10.1186/s40560-015-0120-5

[3] K. Saka, A Akanbi, T Obasa, R. Raheem, A. Oshodi, and Z. Kalgo. "Pathogenic Aerobic Bacterial Contaminants on Non Critical Hospital Surfaces within Paediatric Ward of a Nigerian Hospital." *Journal of Medical Microbiology and Diagnosis*, vol. 05, no. 3, pp. 241, 2016. https://doi:10.4172/2161-0703.1000241

[4] H. Alashoury, and K Othman. "Study of Bacterial Contamination in the Operating Room and Newborn Intensive Care Unit: Effects of the Predominantly Used Antibiotics at Sabratha Teaching Hospital." *Al-Mukhtar Journal of Sciences*, vol. 39, no. 3, pp, 114-123, 2024. https://doi.org/10.54172/qpmrzq98

[5] E. Tacconelli, F. Sifakis and S. Harbarth. "Surveillance for control of antimicrobial resistance." *Lancet Infectious Diseases*, vol. 18, No. 99, pp. 106, 2018. https://doi.org/10.1016/S1473-3099(17)30753-3

[6] C. Rochford, D. Sridhar and N. Woods. "Global governance of antimicrobial resistance." *The Lancet Summit*, vol. 391, no. 10134, pp. 1976-1978, 2018. https://doi.org/10.1016/S0140-6736(18)31117-6

[7] L. Weiner, S. Abner and J. Edwards. "Antimicrobial-resistant pathogens associated with adult healthcare-associated infections: Summary of data reported to the National Healthcare Safety Network." *Infection Control & Hospital Epidemiology*, vol. 41, no. 1, pp. 1-18. 2020. https://doi:10.1017/ice.2019.296

[8] L. Weiner, A. Webb and B. Limbago. "Antimicrobial-Resistant Pathogens Associated with Healthcare Associated Infections Summary of Data Reported to the Antimicrobial-Resistant". *Infectious Control Hospital Epidemiology*, vol. 37, no. 11, pp. 1288-1301. 2019. https://doi: 10.1017/ice.2016.174

[9] S. Magill, W. Hellinger and J. Cohen. "Prevalence of Healthcare Associated Infections in Acute Care Hospitals in Jacksonville Florida." *Infectious Control Hospital Epidemiology*, vol. 33, no. 3, pp. 283-291, 2012. https://doi:10.1086/664048

[10] S. Magill, J. Edwards and W. Bamberg. "Multistate Point-Prevalence Survey of Health Care–Associated Infections for the Emerging Infections Program Healthcare-Associated Infections and Antimicrobial Use Prevalence Survey." *The New England Journal of Medicine*, vol. 370, no. 13, pp. 1198-1208, 2014. https://doi: 10.1056/NEJMoa1306801

[11] S. Salu, J. Okyere, V. Charles and M. Ananga. "Nurses' knowledge on nosocomial infections preventive measures and its associated factors in Ghana: a cross-sectional study". *Health Services Research Health*, vol. 23, no, 1, pp. 1-8. 2023. https://doi:10.1186/s12913-023-09942-2

[12] W. Suksatan, S. Jasim and G. Widjaja. "Assessment effects and risk of nosocomial infection and needle sticks injuries among patents and health care worker." *Toxicology Reports*, vol. 2, no. 9, pp. 284-292. 2022. https://doi: 10.1016/j

[13] T. Worku, D. Derseh and A. Kumalo, "Bacterial Profile and Antimicrobial Susceptibility Pattern of the Isolates from Stethoscope, Thermometer, and Inanimate Surfaces of Mizan-Tepi University Teaching Hospital Southwest Ethiopia." *International Journal of Microbiology*, vol. 2018, no. 1, pp. 9824251, 2018. https://doi:10.1155/2018/9824251

[14] S. Yezli. "surface contamination in operating rooms: a risk for transimission of pathogens." *Surgical Infections*, vol. 15, no. 6, pp. 694-9, 2014. https://doi: CNG90/, 0/68.rtp,1/02, /00

[15] M. Nazeri, J. Salmani, N. Ziloochi, H. Delkhah and M. Hesami. "Microbial contamination of keyboards and electronic equipment of ICU (Intensive Care Units), *Kashan University of* medical sciences and health service hospitals." *MethodsX*. vol. 6, no. 2019, pp. 666-671, 2019. https://doi: 10.1016/j.mex.2019.03

[16] I. Butt, B. Aslam, M. Rasool, H. Shafiq, M. Khurshid and M. Aslam. "Distribution of various pathogenic bacteria from pediatric ward settings." *Saudi Medical Journal*, vol. 37, no. 11, pp. 1268-1271, 2016. https://doi:10.15537/smj.2016.11.15236

[17] C. Agbagwa, and O. Onyebule. "Microbial Population of *Staphylococcus aureus* from Inanimate Surfaces in a General Hospital Environment in Rivers State, Nigeria." *Journal of Applied Sciences and Environmental Management*, vol. 22, no. 1, pp. 124, 2018. http:// doi:dx.doi.org/10.3923/rjf

[18] I. Kilic, M. Ozaslan, I. Karagoz, Y. Zer, E. Sava and V. Davuto. "The role of stethoscopes in the transmission of hospital infections." *African Journal of Biotechnology*, vol. 10, no. 30, pp. 5769- 5772, 2011. https://doi:10.5897/AJB11.295

[19] C. Cruz, M. Aguilar and O. Helguera. "Fungal and bacterial contamination on indoor surfaces of a hospital in Mexico." *Jundishapur Journal of Microbiology Jundishapur*, vol. 5, no. 3, pp. 460-464, 2012. https://doi:10.5812/jjm.2625

[20] N. Gibbons and R. Murray. "Proposals concerning the higher taxa of bacteria." *International Journal of systematic bacteriology*, vol. 28, no. 1, pp. 1-6. 1978. https://doi: 1550-7408

[21] K. Elsayah, A. Atia, and N. Bkhait. "Antimicrobial resistance pattern of bacteria isolated from patients with urinary tract infection in Tripoli city Libya." *Asian Journal of Pharmaceutical and Health Sciences*, vol. 7, no. 4, pp. 1751-1755, 2017. https://doi.org/10.4103/LIMS

[22] M. Salton, and K. Kim. Structure. In: Baron S, editor. "Medical Microbiology." 4th edition. Galveston (TX): University of Texas Medical Branch at Galveston; 1996. Chapter 2. *PMID*: 21413343

[23] A. Atia, A. Abired, A. Ammar, N. Elyounsi and A. Ashour. "Prevalence and types of bacterial infections of the upper respiratory tract at a tertiary care hospital in the City of Tripoli." *Libyan International Medical University Journal*, vol. 3, no. 2, pp. 54-8, 2018. https://doi.org/10.4103/LIMS

[24] World Health Organization. WHO guidelines on hand hygiene in health care (advanced draft): global safety challenge 2005-2006: clean care is safer care. *World Health Organization*. 2006. https://iris.who.int/handle/10665/69323

[25] A. Aiello, J. Cimiotti, P. Latta and E. Larson. "comparison of the bacteria found on the hands of 'homemakers' and neonatal intensive care unit nurses." *Journal of Hospital Infection*, vol. 54, no. 4, pp. 310-5, 2003. https://doi: 10.1016/s0195-6701(03)00146-4

[26] A. Bhalla. N. Pultz. M. Gries, A. Ray, E. Eckstein, D. Aron and C. Donskey, "Acquisition of nosocomial pathogens on hands after contact with environmental surfaces near hospitalized patients." *Infection Control & Hospital Epidemiology*, vol. 25, no. 2, pp. 164-7, 2004. https://doi: 10.1086/502369. PMID: 14994944

[27] S. Won, H. Chou, W. Hsieh, C. Chen, S. Huang, K. Tsou and P. Tsao. "Handwashing program for the prevention of nosocomial infections in a neonatal intensive care unit." *Infection Control & Hospital Epidemiology*, vol. 25, no. 9, pp. 742-6, 2004. https://doi: 10.1086/502470

[28] H. Alashoury, A. Alzawali and H. Abulkasim. "Prevalence of Urinary Tract Infections Among Patients Attending Arriada Laboratory in Alzawia City, Libya." *Wadi Alshatti University Journal for Pure & Applied Science*, vol. 2, no. 1, pp. 95-99, 2024. https://orcid.org/0009-0004-5192-9298

[29] A. Abdulazeez, F. Alsateel1 and O. Masoud. "Isolation and Identification of Bacteria Causing Dental Caries among the Children in Brack Alshatti City." *Wadi Alshatti University*

Journal for Pure & Applied Science, vol. 2, no. 1, pp. 72-78, 2024. https://orcid.org/0009-0002-4936-6946

[30] M. Cheesbrough. (2006). "District laboratory practice in tropical countries." *part 2* (2nd ed.). Cambridge University Press. [32] J. C. Butcher. *Numerical Methods for Ordinary Differential Equations*, 3rd ed. Wiley, 2016

[31] J. Yusuf, O. Okwongo, M. Abubakar K. Babayo, A. Barma M. Ibrahim, A. Sulaiman, H. Hafiz and Z. Bello. "Bacterial Contamination of Intensive Care Units at a Tertiary Hospital in Bauchi, Northeastern Nigeria." *American Journal of Internal Medicine*, Vol. 5, no. 3, pp. 46-51, 2017. https://doi:10.11648/ j. ajim.20170503.13

[32] K. Alghannay, H. Saud, U. Sinniah, I. Safinar B. Ismail, S. Mohamed, S. Isa, A. Alsharif and H. Alashoury. "Evaluation of In-Vitro Antimicrobial Effects of Various Solvents Extracts of Curcuma Zedoaria (Kunyit Putih) Leaves on Selected Gram-Negative and Gram-Positive Bacterial Strains." *Wadi Alshatti University Journal of Pure & Applied Sciences, WAUJPAS*, vol. 3, no. 1, pp. 95-100, 2025. https://orcid.org/0009-0001-3498-0735

[33] K. Hassan. "Antimicrobial Activity and Synergistic Effects of Libyan Extracts from Artemisia Herbaalba, Thymus Vulgaris, and Zingiber Officinale Against ATCC Strains of Bacillus Subtilis and Escherichia Coli." *Wadi Alshatti University Journal of Pure and Applied Sciences*, vol. 4, no. 2, pp. 215-222, 2026. https://orcid.org/0009-0001-8644-2621

[34] R. Ssekitoleko, S. Oshabaheebwa and I. Munabi. "The role of medical equipment in the spread of nosocomial infections: a cross-sectional study in four tertiary public health facilities in *Uganda." BMC Public Health*, vol. 20, no.1, pp. 1-11, 2020. https://doi:10.1186/s12889-020-09662-w

[35] E. Thompson, A. Badu and E. Abban. "Bacterial contamination on clinical surfaces and oxygen device accessories in the emergency unit of a tertiary health facility in Ghana." *BMC Infectious Diseases*, vol. 24, no. 1, pp. 1-9, 2024. https://doi:10.1186/s12879-023-08894-6

[36] F. Ogunsola, and S. Mehtar. "Challenges regarding the control of environmental sources of contamination in healthcare settings in low-and middle-income countries - A narrative review." *A ntimicrobial Resistance Infection Control*, vol. 9, no. 1, pp. 1-9, 2020. https://doi:10.1186/s13756-020-00747-0

[37] D. Ngambi, T. Byrne and E. Jingini. "An assessment of infection prevention and control implementation in Malawian hospitals using the WHO Infection Prevention and Control Assessment Framework (IPCAF) tool." *Infection Prevention in Practice*, vol. 6, no. 4, pp. 100388, 2024. https:// doi: 10.1016/j.infpip.2024.100388

[38] I. Sserwadda, M. Lukenge, B. Mwambi, G. Mboowa, A. Walusimbi and F. Segujja." Microbial contaminants isolated from items and work surfaces in the postoperative ward at Kawolo general hospital, Uganda." *BMC Infectious Disease*, vol. 18, no. 68, pp. 1-6, 2018. https://doi. 10.1186/s12879-018-2980-5

[39] E. Ahmed, H. Allah, N. El-sherbiny and A. Soliman. "Bacteriological Monitoring of Inanimate Surfaces and Equipment in Some Referral Hospitals in Assiut City, Egypt." *International Journal of Microbiology*, vol. 2019, no. 1, pp. 1-9, 2019. https://doi: 10.48084/*etasr*.7262

[40] Z. Laizer, I. Philbert, A. Charles, K. Jovin, R Tibendarana1 S. Maghembe1 A. Shayo, S. Mkumbaye, N. Kassam and D. Kajeguka. "Bacterial Contamination of Inanimate Surfaces and Equipment, Distribution and Susceptibility Patterns in Pediatric Wards at a Northern Tanzania Zonal Referral Hospital." *medRxiv preprin*, vol. 5, no. 1, pp 1-22, 2025. https://doi: https://doi.org/10.1101/2025.07.08.25331103

[41] J. Emhalhel. " Prevalence and Antimicrobial Resistance of Gram-Negative Bacteria in Clinical and Environmental Samples: A Study from Libya." *Libyan Medical Journal*, vol. 17, no. 3, pp. 351-354, 2025. https://doi.org/10.69667/lmj.2517307

[42] T. Azimi, S. Maham, F. Fallah, L. Azimi and Z. Gholinejad. "Evaluating the antimicrobial resistance patterns among major bacterial pathogens isolated from clinical specimens taken from patients in mofid children's hospital, Tehran, Iran: 2013–2018." *Infection and Drug Resistance*, vol. 9, no. 12, pp. 2089-2102, 2019. https://doi:10.2147/IDR.S215329

[43] R. Maghembe, M. Magulye and A. Makaranga. "Comprehensive genomics reveals novel sequence types of multidrug resistant Klebsiella oxytoca with uncharacterized capsular polysaccharide K- and lipopolysaccharide O-antigen loci from the National Hospital of Uganda." *Infection, Genetics and Evolution Journal*, vol. 123, no. 2024, pp. 105640, 2024. https://doi: 10.1016/j.meegid.2024.105640

[44] K. Saka, I. Akanbi, T. Obasa, R. Raheem, A. Oshodi and Z. Kalgo. " Pathogenic Aerobic Bacterial Contaminants on Non-Critical Hospital Surfaces within Paediatric Ward of a Nigerian Hospital." *Journal of Medical Microbiology and Diagnosis*, vol. 5, no. 3, pp.1000241, 2016. https://doi:10.4172/2161-0703.1000241

[45] M. Tohidnia, J. Dezfolimanesh and A. Almasi. "Bacterial contamination of radiography equipment in radiology departments of Kermanshah University of Medical Sciences 2010." *Journal of Kermanshah University of Medical Sciences*, vol. 16, no. 3, pp. 273-6, 2013. https://doi: 10.6812/ermsj-150758

[46] A. Atia. "Antibiotic resistance in Libya and the prevalence of antibiotic self-medication:" A review. *Razi Medical Journal*, vol. 1, no. 1, pp. 2-6. 2025. https://doi.org/10.4103/LIMS

[47] S. Ensayef, S. Al-Shalchi and M. Sabbar. "Microbial contamination in the operating theatre: Hospital in Baghdad." *Eastern Mediterranean Health Journal*, vol. 15, no. 1, pp. 219-23, 2009. https://doi: 10.54172/qpmrzq98

[48] A. Peleg and D. Hooper. "Hospital-acquired infections due to gram-negative bacteria." *The New England Journal of Medicine*, vol. 13, no. 19, pp. 1804- 13. 2010. https://doi: 10.1056/NEJMra0904124

[49] U. Muhammad, M. Isa and Z. Aliyu. "Distribution of potential nosocomial pathogens isolated from environments of four selected hospitals in Sokoto, North Western Nigeria." *Journal of Microbiology and Biotechnology Research*. 2013, vol. 3, no.1, pp. 139-4, 2013. https://doi.org/10.4324/9780203706947

[50] N. Taheri, H. Abtahi and A. Nobaveh. "The antibiotic resistant determinant of pathogenic bacteria isolated from medical equipment and hospital environment in Valiasr Hospital, Arak, 2013." *Journal Mazandaran University of Medical Sciences*, vol. 24, no. 114, pp. 60-73, 2014. https://doi.org/10.5001/omj