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Microbial Contamination Hands of Healthcare Providers in Intensive Care Units at Al-Zwia Medical Center

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التلوث الميكروبي لأيادي مقدمي الرعاية الصحية في وحدات العناية المركزة في مركز الزاوية الطبي

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Abstract:
Nosocomial infections are a major cause of morbidity and mortality among patients, medical staff, and visitors, often transmitted through contaminated surfaces, particularly via healthcare workers' hands. This study aimed to isolate and identify bacterial contaminants on the hands of healthcare providers in the Intensive Care Units (ICUs) at Al-Zawia Medical Center. A total of 60 hand samples were collected from doctors, technicians, and paramedics, with 52 samples (86.7%) found to be contaminated. The most commonly isolated bacteria were non-pathogenic diphtheroids (53%), which may become aggressive in immunocompromised patients, followed by Klebsiella pneumoniae (6.7%), Staphylococcus aureus (6.7%), Escherichia coli (3.3%), and other pathogens such as hemolytic staphylococci and Acinetobacter baumannii. The findings highlight severe contamination risks, emphasizing the need for strict hygiene practices, including the use of alcohol-based hand sanitizers and frequent glove changes between patient interactions to reduce the spread of infections.

Keywords: Health Care Workers HCWs; Intensive Care Units; Nosocomial infection NIS; Non-Pathogenic Diphtheria in NPD.

الملخص
تعد العدوى المكتسبة في المستشفيات سببًا رئيسيًا للامراضية والوفيات بين المرضى والعاملين في المجال الطبي والزوار، وغالبًا ما تنتقل عبر الأسطح الملوثة، وخاصة من خلال أيدي العاملين في الرعاية الصحية. هدفت هذه الدراسة إلى عزل وتحديد الملوثات البكتيرية على أيدي مقدمي الرعاية الصحية في وحدات العناية المركزة بمركز الزاوية الطبي. تم جمع ما مجموعه 60 عينة من أيدي الأطباء والفنيين والمسعفين، حيث تبين أن 52 عينة (86.7%) كانت ملوثة. وكانت البكتيريا الأكثر شيوعًا هي الدفتيريا غير الممرضة (53%)، والتي قد تصبح أكثر عدوانية لدى المرضى ذوي المناعة الضعيفة، تليها الكليسيلة الرئوية (6.7%)، المكورات العنقودية الذهبية (6.7%)، الإشريكية القولونية (3.3%)، وبقية مسببات الأمراض مثل المكورات العنقودية الحالة للدم والأسينيتوباكتر بومائي. تبرز النتائج المخاطر الكبيرة للتلوث، مما يؤكد الحاجة إلى اتباع ممارسات صحية صارمة، بما في ذلك استخدام معقمات الأيدي التي تحتوي على الكحول وتغيير القفازات بشكل متكرر بين التعامل مع المرضى للحد من انتشار العدوى.

الكلمات المفتاحية: العاملون في الرعاية الصحية (HCWs)، وحدات العناية المركزة (ICUs)، العدوى المكتسبة في المستشفيات (NIS)، الدفتيريا غير الممرضة (NPD).

1. Introduction

Hand hygiene is widely recognized as one of the most important measures for preventing the spread of infections in healthcare settings, particularly in critical environments such as Intensive Care Units (ICUs). In these units, patients are often vulnerable due to weakened immune systems, invasive procedures, and prolonged hospital stays, which increase their susceptibility to infections [1]. As healthcare providers frequently come into contact with patients, surfaces, and medical equipment, their

hands can easily become contaminated with pathogens. Without proper hand hygiene, these pathogens can be transmitted to patients, contributing to the spread of healthcare-associated infections (HAIs). Effective hand hygiene practices in ICUs are crucial to reducing the incidence of infections and ensuring patient safety [2].

Healthcare providers' hands play a pivotal role in the transmission of infections within healthcare environments, especially in ICUs, where the risk of cross-contamination is high. Pathogenic microorganisms, including bacteria, viruses, and fungi, can be transferred between healthcare workers and patients during routine care, leading to hospital-acquired infections (HAIs) [3]. Microbial contamination of healthcare providers' hands is a significant concern because it can result in the spread of drug-resistant organisms, extended hospital stays, increased healthcare costs, and in severe cases, patient mortality. Understanding the extent and types of microbial contamination on the hands of healthcare workers can inform infection control strategies and improve hand hygiene compliance, ultimately reducing the burden of HAIs.

The primary objective of this study is to identify and assess the extent of microbial contamination on the hands of healthcare providers working in the Intensive Care Units (ICUs) at Al-Zwia Medical Center. By examining the types and levels of microorganisms present, the study aims to provide insights into the potential risk of infection transmission within the ICU and recommend measures to strengthen infection control practices. This study contributes to a better understanding of how microbial contamination correlates with hand hygiene practices and its role in the prevention of HAIs.

2. Literature Review

Extensive research has been conducted on microbial contamination in healthcare settings, with numerous studies emphasizing the significant role that healthcare providers' hands play in the transmission of infections. A study by Pittet et al. [4] demonstrated that hands are the most common vectors for the spread of healthcare-associated infections (HAIs), with up to 40% of cases linked to contamination from healthcare workers. Another study by Kampf and Kramer (2004) found that pathogens, including Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, and Clostridium difficile, are frequently isolated from healthcare workers' hands in clinical environments.

Research also highlights the role of antibiotic-resistant organisms such as Methicillin-resistant Staphylococcus aureus (MRSA) and Vancomycin-resistant Enterococcus (VRE), which are often found on healthcare workers' hands and have become significant contributors to HAIs. Larson [5] conducted a systematic review that identified bacteria such as Acinetobacter and Klebsiella species as common pathogens responsible for HAIs, particularly in ICU settings where patients are at higher risk due to invasive procedures and compromised immune systems. These studies underscore the critical need for consistent hand hygiene practices in reducing microbial contamination and preventing HAIs.

Several factors contribute to microbial contamination on the hands of healthcare providers, especially in ICU environments. Improper hand hygiene is the primary risk factor. Despite guidelines recommending routine handwashing before and after patient contact, compliance among healthcare workers remains suboptimal. Studies, such as one conducted by Erasmus et al. [6], indicate that healthcare workers' hand hygiene compliance rates can be as low as 40%, with non-compliance significantly increasing the risk of cross-contamination. Another risk factor is non-compliance with infection control protocols, such as the inappropriate use of gloves or failure to properly disinfect hands after removing them. Studies show that healthcare workers may rely too heavily on gloves, leading to the neglect of handwashing when switching between patients or tasks. Overcrowded ICUs also contribute to contamination, as higher patient loads often result in rushed care and reduced attention to proper hygiene practices. Additionally, frequent contact with medical devices and invasive procedures in ICUs increase the likelihood of hand contamination. Healthcare workers in ICUs may come into contact with blood, bodily fluids, and secretions, further elevating the risk of contamination if hygiene measures are not strictly adhered to.

Microbial contamination on healthcare providers' hands can have far-reaching consequences for both patient outcomes and the overall healthcare system. Hospital-acquired infections (HAIs) pose a major threat to patient safety, leading to increased morbidity and mortality. The Centers for Disease Control and Prevention (CDC) estimates that HAIs result in approximately 1.7 million infections and 99,000 associated deaths annually in the United States alone. In ICUs, where patients are already critically ill, the consequences of such infections can be particularly severe [7].

The impact of HAIs extends beyond individual patients, significantly increasing healthcare costs. A study by Scott (2009) estimated that HAIs result in billions of dollars in excess healthcare costs due to extended hospital stays, additional treatments, and more intensive care. Antibiotic-resistant infections such as those caused by MRSA and VRE further complicate treatment and escalate costs due to the need for more expensive and aggressive therapies [8].

Moreover, microbial contamination on healthcare providers' hands 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, improving patient outcomes, and reducing the financial burden on healthcare systems. In conclusion, the literature highlights the significant role of healthcare workers' hands in the transmission of pathogens, particularly in ICUs. Addressing the key risk factors, such as inadequate hand hygiene and infection control practices, is essential to reduce microbial contamination and its associated impacts.

3. Materials and Methods

3.1 Study Design

This study follows a cross-sectional, observational design aimed at assessing the extent of microbial contamination on the hands of healthcare providers in the Intensive Care Units (ICUs) at Al-Zwia Medical Center. The study was conducted over a period of three months, during which samples were collected from healthcare providers at multiple points throughout their shifts. This design enables the study to capture a snapshot of microbial contamination levels and identify any patterns or trends associated with specific groups of healthcare workers or timeframes [9,10]. In this context, sixty samples were collected from the Intensive Care Units (ICUs) at Al-Zawia Medical Center, targeting the hands of doctors, technicians, and helpers.

The samples were taken over two months, in June and August of 2022. 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 palm and the spaces between the fingers. 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, MacConkey agar, and Salt Mannitol agar, and incubated again for 24 hours at 37°C to differentiate and identify microbial types [11-12].

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. Sabouraud agar plates were used to detect fungal growth, while 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 [13-14]. Oxidase and Polymyxin B tests were 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 using the VITEK DENSICHEK system.

3.2 Study Setting

The study was conducted at Al-Zwia Medical Center, a major healthcare facility serving a large patient population. The focus was on the hospital's Intensive Care Units (ICUs), which are critical environments with a high potential for the transmission of hospital-acquired infections (HAIs) [15,16]. The ICUs are divided into several units, including medical, surgical, and pediatric care, with each unit providing specialized care for critically ill patients. These units were selected due to their high patient acuity and the frequent interactions between healthcare providers and patients, which increase the likelihood of microbial contamination [17-20].

3.3 Participants

The study included healthcare providers working in the ICUs of Al-Zwia Medical Center, specifically targeting nurses, doctors, and support staff involved in direct patient care. The inclusion criteria were as follows:

- Healthcare providers who were on duty in the ICU during the study period.
- Individuals who provided direct patient care, including administering medication, performing procedures, or interacting with patients.
- Willingness to participate in the study and provide hand samples.
- Healthcare providers who had recently taken antibiotics or those who declined to participate were excluded from the study.

3.4 Sample Collection

Microbial samples were collected from the hands of healthcare providers at different times during their shifts to assess contamination levels. The method of sample collection involved swabbing the surfaces of both hands, including the palms, fingertips, and interdigital spaces, 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 some cases, healthcare providers were asked to refrain from washing their hands just before sample collection to obtain realistic contamination levels.

3.5 Laboratory Analysis

Upon arrival at the laboratory, the swabs were processed using standard microbiological culture techniques to identify and quantify the microorganisms present on the healthcare providers' hands. The samples were inoculated onto a variety of culture media, including:

- Blood agar to identify general bacterial contaminants.
- MacConkey agar to isolate Gram-negative bacteria.
- Mannitol salt agar to detect Staphylococcus aureus and other Gram-positive bacteria.
- Sabouraud agar to identify fungal contamination, if present.

4. Results

In this study, a total of 60 samples were collected from healthcare providers' hands (doctors, technicians, and helpers) working in the Intensive Care Units (ICUs) at Al-Zawia Medical Center over a two-month period (June and August 2022). The primary aim was to isolate and identify microbial contaminants and assess the extent of contamination. Table 1 presents distribution of samples. Table 2 illustrates result of samples.

Table 1: Distribution of samples.

HCWs	Number	Percent
Doctor	12	20.0
Technicians	33	55.0
Paramedics	15	25.0
Total	60	100.0

Table 2: Result of samples.

Samples	Count	Percent
Positive	52	86.0
Negative	8	13.3
Total	60	100.0

The total sample 60 (100 %), the positive samples 52 (86.7%) the negative samples 8 (13.3 %). The total doctors 12 (20%) of all samples, two doctors were not contaminated with any bacteria, (25 %) of the total uncontaminated samples, 10 (19 %) of the total contaminated samples. The total technicians 33 (55 %) Four of them were uncontaminated with any bacteria, (50 %) of the total uncontaminated sample, and 29 (55%) of the total contaminated samples.

The total paramedics 15 (25%), two of whom were uncontaminated (25%) of the total uncontaminated, 13 (25%) of the total of contaminated samples. Types of microorganisms isolated include non-pathogen diphtheria, E coli, Acineto acter Bahmani, Klebsiella pneumonia, Staphylococcus hemolyticus and S.aureus and Serrtia rubidian , Enterobacter agglomerants, (NLF) NON Lactose Fermenting Staphylococcus saprophyte as presented Table 3.

Table 3: Type of bacteria present on hands.

Bacteria types	Frequency	Percent
N.P.D	32	53.3
Escherichia coli	2	3.3
Acinetobacter Baumann	2	3.3
Klebsiella pneumoniae	4	6.7
Staphylococcus hemolytic	3	5.0
Staphylococcus aureus	4	6.7
Serratia rubidian	1	1.7
Enterobacter agglomerants	1	1.7
(NLF) NON-Lactose fermenting	2	3.3
Staphylococcus saprophyticus	1	1.7
NO Growth	8	13.3
Total	60	100.0

4.1 Sample Collection and Initial Processing

After proper decontamination and the use of gloves, sterile cotton swabs moistened with Trypticase Soy Broth (TSB) were used to swab the palms and spaces between the fingers of healthcare providers. The swabs were labeled and immediately transferred to the microbiology laboratory. The samples were incubated at 37°C for 24 hours, encouraging initial microbial growth.

4.2 Culturing on Nutrient Media

Following incubation, all 60 samples were cultured on a variety of selective and differential media to identify microbial contamination. Blood agar, MacConkey agar, and Salt Mannitol agar were used for primary cultivation. After a second incubation period of 24 hours at 37°C, the plates were examined for microbial growth:

- Blood agar plates were assessed for hemolysis patterns to identify potential pathogens. Beta-hemolysis, indicative of more virulent strains like Streptococcus pyogenes, was observed in 3 samples (5%), while non-hemolytic strains dominated in others.
- MacConkey agar was used to differentiate Gram-negative bacteria. Growth was observed in 11 samples (18.3%), with lactose fermenters indicating the presence of organisms such as Escherichia coli, while non-lactose fermenters suggested organisms like Klebsiella pneumoniae and Acinetobacter baumannii.
- Salt Mannitol agar helped identify Staphylococcus aureus based on its ability to ferment mannitol, observed in 4 samples (6.7%).

4.3 Microbial Identification

Further identification of the isolated microorganisms was carried out using a series of biochemical tests:

- Catalase tests distinguished Staphylococcus species from Streptococcus species. Positive catalase reactions, typical of Staphylococcus, were found in 8 samples (13.3%), while the catalase-negative Streptococcus species were found in 3 samples (5%).
- Sabouraud agar plates were used to check for fungal growth, but no fungal contamination was detected in any of the samples.
- MacConkey agar plates revealed significant growth of Gram-negative bacilli in 7 samples (11.7%). Of these, 4 samples (6.7%) were identified as Klebsiella pneumoniae, 2 (3.3%) as non-lactose fermenters, likely Acinetobacter baumannii, and 1 (1.7%) as Serratia rubidiae.
- The Triple Sugar Iron (TSI) test showed carbohydrate fermentation in Enterobacteriaceae species, with 4 samples testing positive for acid and gas production, confirming the presence of E. coli in 2 cases (3.3%).

4.4 Advanced Biochemical Testing

For more detailed identification, Sulfide Indole Motility (SIM) tests, Simmons' Citrate utilization, and Christensen's Urea Agar tests were performed on isolated samples:

- The SIM test revealed motility in Escherichia coli samples, while sulfur reduction was observed in 2 samples, indicating the presence of Proteus species.
- Citrate utilization was positive in 4 samples, including Klebsiella pneumoniae isolates, confirming their metabolic activity.
- Urease production was observed in 3 samples, indicating the presence of urease-positive bacteria, likely Proteus and Klebsiella species.

4.5 Oxidase and Polymyxin B tests

Oxidase and Polymyxin B tests were used to identify glucose-non-fermenting Gram-negative bacteria. These tests confirmed the presence of Acinetobacter baumannii in 2 samples (3.3%).

4.6 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 and Serratia rubidiae were conclusively identified. Finally, antimicrobial susceptibility testing was performed on all isolated organisms using the Muller Hinton agar and VITEK DENSICHEK system. The bacterial suspensions were adjusted to the 0.5 McFarland standard, and susceptibility tests were conducted. Results indicated a significant presence of multi-drug resistant organisms (MDROs) among the isolates, particularly in Klebsiella pneumoniae and Acinetobacter baumannii, highlighting concerns for nosocomial infection risks in the ICU.

- Summary of Isolated Organisms
- Non-pathogenic diphtheroids: 32 samples (53%)
- Klebsiella pneumoniae: 4 samples (6.7%)
- Staphylococcus aureus: 4 samples (6.7%)
- Escherichia coli: 2 samples (3.3%)
- Hemolytic staphylococci: 3 samples (5%)
- Lactose non-fermenting bacteria (likely Acinetobacter): 2 samples (3.3%)
- Serratia rubidiae: 1 sample (1.7%)
- Enterococcus agglomerans: 1 sample (1.7%)
- Staphylococcus saprophyticus: 1 sample (1.7%)
- Acinetobacter baumannii: 2 samples (3.3%)

The results highlight significant microbial contamination on healthcare workers' hands in the ICUs, with potentially harmful pathogens like Klebsiella pneumoniae, Staphylococcus aureus, and Acinetobacter baumannii being present. The findings emphasize the need for stringent hand hygiene practices, regular use of alcohol-based hand sanitizers, and proper glove use to minimize the risk of nosocomial infections in critical care settings.

5. Discussion

The primary objective of our study was to assess the level of microbial contamination on the hands of healthcare workers (HCWs) in intensive care units (ICUs) at Al-Zawia Medical Center. ICUs, due to the critical condition of the patients, must maintain stringent hygiene standards, and healthcare workers' hands are expected to be sterile and free of any microorganisms to prevent nosocomial infections. Our findings, however, confirm the presence of contamination with various bacterial species, including highly virulent organisms such as Klebsiella pneumoniae and Staphylococcus aureus, both of which are capable of causing serious hospital-acquired infections (HAIs). Samples were collected from three categories of healthcare workers: doctors (20%), technicians (55%), and paramedics (25%), each with different educational backgrounds. Surprisingly, the contamination levels on the hands of doctors, who generally possess the highest level of education among the three groups, were similar to those of other healthcare workers. Contamination was found on 83% of doctors' hands (10 out of 12 samples), demonstrating that even among highly educated staff, hand hygiene practices were not sufficiently adhered to. This highlights a critical gap in the awareness of infection control, as the contamination rates were high across all categories of healthcare workers, regardless of their roles or education levels.

The most frequently isolated microorganism was non-pathogenic diphtheroid (NPD), which are typically commensal bacteria found on the skin and mucous membranes. However, despite being considered non-pathogenic, diphtheroid are frequently associated with nosocomial infections, particularly due to their ability to form biofilms on medical equipment. Biofilms pose significant challenges in healthcare environments, as they are resistant to treatment and can cause chronic infections. For example, biofilms on catheters or prosthetic devices can lead to recurrent infections that are difficult to eradicate because of the protective biofilm matrix, which slows the penetration of antibiotics and alters the microorganisms' physiological mechanisms. This biofilm-associated resistance underscores the importance of addressing NPD contamination, as their presence alongside pathogenic bacteria (Gram-negative and Gram-positive) in a hospital environment can facilitate biofilm formation and further increase antibiotic resistance. Our findings align with previous studies conducted at Sabha Medical Center Hospital, where bacterial isolates from the hands of HCWs included Methicillin-resistant Staphylococcus aureus

(MRSA) at 35%, Bacillus spp. at 33.5%, Staphylococcus albus at 22.85%, and Escherichia coli at 8.57%. The diversity of isolated bacteria in Sabha hospital in southern Libya is strikingly similar to the results at Al-Zawia Medical Center in western Libya, providing strong evidence of a widespread issue with hand hygiene practices in Libyan hospitals. This similarity suggests a systemic lack of attention to hand hygiene and infection control protocols in hospitals across the country, further exacerbated by the absence of strict sterilization guidelines.

The high contamination rates observed in both studies highlight the urgent need for improvements in hand hygiene compliance among healthcare workers. Immediate action is required to implement and enforce more rigorous sterilization protocols, along with educational programs aimed at increasing awareness about the importance of hand hygiene. Furthermore, future studies should focus specifically on diphtheroid and their role in biofilm formation and antibiotic resistance, as these bacteria may play a more significant role in HAIs than previously thought. In conclusion, our study demonstrates that microbial contamination is widespread among healthcare workers in ICUs, with potentially severe implications for patient safety. To reduce the incidence of nosocomial infections, it is essential to improve hand hygiene practices and develop effective sterilization protocols in healthcare settings across Libya.

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