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*Original article*

# Mobile Phones and Multidrug Resistant Bacteria: A Growing Concern for Healthcare Workers

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***Keywords***:

*Multidrug Resistance, Bacteria, Mobile Phones, Healthcare Workers, Antibiotics.*

Healthcare workers' mobile phones can potentially transmit a range of pathogenic bacteria causing Hospital acquired infections to patients and community. The study was conducted to determine the prevalence of bacterial contamination of mobile phones of healthcare workers, assessing the kinds of bacterial isolates, their antibiotic susceptibility and resistance patterns, and the factors contributing to contamination. A cross-sectional study was conducted at Elhwari Nephro Center including 125 health care workers. Demographic data, and data regarding antibiotic usage history as well as mobile cleaning behaviour were collected using a structured questionnaire. Antimicrobial susceptibility testing was performed for all the collected mobile swabs samples. Data analysis using SPSS version 28. Prevalence rates of resistant micro-organisms were revealed together with the corresponding patterns of antibiotic susceptibility. Results are presented using tables for clarity. The overall prevalence of mobile phone contamination was 84% of swabbed samples. The most common bacterial isolate was pseudomonas aeruginosa 21.6% followed by E. coli 20.8%, staphylococcus epidermidis 16.8%, Klebsiella pneumonia 14.4%, staphylococcus aureus 6.4%, and clostridium spp 4%. Most isolates were susceptible to levofloxacin (98.1%), ciprofloxacin (88.6%), and ceftriaxone (84.8%). Vancomycin showed limited effectiveness specifically against staphylococcus aureus with only 13% susceptibility. 86.7% and 71.2% of bacterial isolates were resistant to erythromycin and clindamycin respectively. No significant correlation was found between mobile phone contamination and different participant variables such as gender, age, occupation, mobile phone usage and hygiene practices. The overall prevalence of multidrug-resistant bacteria was 80%. This study points out the scary role that mobile phones play in the dissemination of multidrug-resistant organisms and the urgent need to revisit policies on the use of antibiotics, as well as the reinforcement of antibiotic stewardship.

## Introduction

Hospital-acquired infections (HAIs) are a growing global concern, primarily caused by bacteria that are becoming more resistant to common antibiotics [1,2]. The bacterial infections are responsible for at least 90% of cases diagnosed in hospitals, the sources of which may be either exogenous or endogenous in origin [3]. One of the main sources of such pathogens is from healthcare environments and equipment themselves [3-5]. The high prevalence of HAIs heightens the morbidity and mortality of hospitalised patients, particularly in the most vulnerable populations such as surgical patients, pregnant women, immunocompromised patients, and patients with chronic diseases [1,6]. Hand hygiene practices are critical in reducing the spread of HAIs, especially in resource-limited settings; however, compliance remains a challenge [2,3,7]. While cleaning protocols typically include stethoscopes and medical equipment [2,8], many healthcare workers neglect to regularly clean their mobile devices or practice adequate hand washing after use [1,3,5,7].

Mobile phones, which are even more contaminated than common sources of bacteria such as shoe soles and doorknobs [4, 5, 7], represent a serious danger due to their capability of hosting pathogenic bacteria, especially in hot and humid climates [8].

Frequent handling of these devices in clinical settings, without proper hygiene practices, by healthcare workers (HCWs), encourage the spread of various pathogens, including such multidrug-resistant strains as staphylococcus aureus, Escherichia coli, pseudomonas aeruginosa, and klebsiella pneumoniae, that can cause serious health risks for both patients and healthcare professionals [1,6,7,9-11]. Previous studies have

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shown that 75–96% of healthcare workers' mobile phones in high-income countries had bacterial colonization [4,11]. On the other hand, the percentage of healthcare workers' mobile phones that were contaminated by bacteria varied from 42% to 100% in low- and middle-income countries [4,11].
In the developing world, there is a significant lack of awareness about the risk of mobile phone contamination [8]. Health care professionals commonly neglect the possibility of these phones serving as a reservoir and transmitter of pathogens, especially during patient contact in high-risk areas such as operating rooms and intensive care units [3,12]. Furthermore, sharing of the mobile phones by healthcare workers and non-healthcare workers can increase the risk of cross-contamination in the community and make infection control more difficult [3,6-8].
In spite of the advantages of mobile technology in accessing clinical information and simplifying clinical workflow, microbial contamination remains a challenge [11,13]. Mobile device sanitation on a regular basis must be part of infection control programs to reduce the transmission of HAIs and promote patient safety [2,11,14].
The emerging trend of antimicrobial resistance creates severe handicaps in the battle against HAIs because most pathogens are resistant to several antibiotics [1,2,6,7,9,11,14]. The antibiotic resistance not only complicates the treatment of infections but also adds to healthcare expenses through increased hospitalization and more costly alternative therapies [10]. These situations lead to greater stress for patients and their families, as well as an overall lower quality of life for those afflicted [14]. Although mobile phones are essential devices in modern health care, their role as carriers of pathogens underscores the necessity of better hygiene practices to prevent HAIs. Thus, the purpose of this study was to assess the prevalence of bacterial contamination on mobile phones used by healthcare workers, evaluating the types of bacterial isolates present, their antimicrobial susceptibility and resistance patterns, and the factors contributing to contamination.

## Methods

### *Study design and samples*

A cross-sectional study was conducted with the view to determine the prevalence of resistant microorganisms and their patterns of antibiotic susceptibility among healthcare workers at Elhwari Nephro Center. We targeted 125 participants including physicians, nurses, laboratory technicians, and the support staff. The inclusion criteria were all those healthcare workers having direct contact with patients and willing to participate in the study. The exclusion criteria included people who did not come into direct contact with the patients and those not willing to participate in the study.

### *Data collection*

There were two major elements that made up the information gathering in this study; which were microbiological sampling and demographic data. The information used for the demographic parts was obtained by a standardized questionnaire which sought to provide answers concerning participants' age, gender, occupation, antibiotic usage history as well as mobile cleaning behaviour.
Sterile mobile phone swabs were used to obtain microbiological samples from the healthcare workers. All the samples were labelled appropriately and, within two hours, were transported to the microbiology laboratory in aseptic conditions for analysis.

### *Microbiological analysis*

Swabs were inoculated in blood agar plates (BAP), MacConkey agar, and chocolate agar (CAP) for the isolation of bacteria. The inoculated agar plates were incubated at 37°C for 24 to 48 hours. Gram response, colony features, haemolysis on blood agar and physical appearance variations in differential media were used in making the presumptive identification of the bacterium. Various biochemical assays were also done to further identify the bacteria based on the gram responses that were produced. Gram-negative bacteria were identified by use of Simon's citrate agar, urease, indole and triple sugar iron agar. Gram-positive bacteria were identified by using bacitracin sensitivity, coagulase, and catalase.
Antimicrobial susceptibility testing was performed by the Kirby-Bauer disk diffusion technique according to the recommendations of the Clinical and Laboratory Standards Institute (CLSI). A panel of commonly used antibiotics was selected for testing against isolated strains.

### *Statistical analysis*

Statistical software SPSS version 28 was used in the analysis. Descriptive statistics were carried out for the prevalence rates of resistant bacteria and demographic variables. Chi-square tests were used to test for associations among categorical variables. P-values of <0.05 were considered statistically significant.

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Prevalence rates of resistant micro-organisms were revealed together with the corresponding patterns of antibiotic susceptibility. Results are presented using tables for clarity.

***Ethical consideration***

The protocol was approved by the Nephro Centre before the commencement of the study. Informed consent was taken from all the participants after explaining the purpose of the study to them and guaranteeing confidentiality over their responses.

## Results

***Demographic characteristics of health care workers:***

The study involved the recruitment of 125 participants, 89 (71.2%) of whom were female. Doctors made up the largest group (36%), followed by nurses (32.8%), technicians (22.4%), and healthcare assistants (8.8%). Most participants had a Bachelor's degree (38.4%), followed by Higher Diploma (32.0%) and Intermediate Diploma (27.2%). Advanced degrees (Master's and Doctorate) were rare, accounting for 0.8% and 1.6%, respectively. Participants in the study had an average age of 33.56 (±8.112) years. The majority of study participants (45.6%) were between the ages of 19 and 30, followed by those between the ages of 31 and 41 (36.0%), and those above 41 (18.4%). Table1 presents the demographic characteristics of healthcare workers.

***Table 1. Demographic characteristics of health Care Workers (n = 125)***

| Demographic characteristics | Item | N | % |
|---|---|---|---|
| **Gender** | Female | 89 | 71.2% |
| | Male | 36 | 28.8% |
| **Age in year** | 19-30 | 57 | 45.6% |
| | 31-41 | 45 | 36.0% |
| | >41 | 23 | 18.4% |
| **Occupation** | Doctor | 45 | 36% |
| | Nurse | 41 | 32.8% |
| | Technician | 28 | 22.4% |
| | Healthcare assistant | 11 | 8.8% |
| **Level of Education** | Bachelor's | 48 | 38.4% |
| | Higher Diploma | 40 | 32.0% |
| | Intermediate Diploma | 34 | 27.2% |
| | master | 1 | 0.8% |
| | Doctor | 2 | 1.6% |

***Mobile phone usage, hygiene practices and antibiotic misuse:***

In this study, 82.4% of the participants had one mobile phone, whereas 17.6% had two, and 69.6% of them used protective covers for their phones. Even though the majority of survey participants (88.8%) thought that mobile phones might harbor pathogens; 88% of them continued to use their phones while in the hospital, and 95.2% of them used the same phone at home, emphasizing the possibility of cross-contamination. Moreover, the study found that 42.4%% of participants shared their phones with family members and 25.6% shared them with co-workers. Alarmingly, mobile phones are carried by 60% of survey participants together with other patient care supplies, which was significantly lower among technicians (32.1%) compared to doctors (82.2%), and 72.8% of participants acknowledged using their phones while attending the patient; this behaviour was most prominent among doctors (82.2%) and technicians (75%). Sharing with colleagues was least common among doctors (22.2%) and most common among nurses (39%). Whereas, sharing with family members was highest among nurses (43.9%) (Table 1).

Despite the widespread use of mobile phones in medical settings, participants' awareness of hygiene varied. Approximately 70.4% of participants cleaned their phones on a regular basis, 67.2% washed their hands after using their phones, and 92.8% cleansed their hands before treating patients. Regular cleaning of mobile phone was highest among technicians (78.6%) followed by doctors (68.8%). Among the participants, 5.6% reported using antibiotics without prescription, while 17.6% acknowledged using antibiotics carelessly or for longer than was necessary. Characteristics data of mobile phone usage, hygiene practices and antibiotic misuse are shown in table 2.

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***Table 2. Characteristics of mobile phone usage and hygiene practices (n= 125)***

| Characteristics | | Yes | No |
|---|---|---|---|
| Mobile phone with cover | N | 87 | 38 |
| | % | 69.6% | 30.4% |
| Use mobile phone in the hospital | N | 110 | 15 |
| | % | 88.0% | 12.0% |
| Use the same mobile phone at home | N | 119 | 6 |
| | % | 95.2% | 4.8% |
| Share mobile phone with colleagues | N | 32 | 93 |
| | % | 25.6% | 74.4% |
| Share mobile phone with family member | N | 53 | 72 |
| | % | 42.4% | 57.6% |
| Use mobile phone while attend patient | N | 91 | 34 |
| | % | 72.8% | 27.2% |
| Regular mobile phone cleaning | N | 88 | 37 |
| | % | 70.4% | 29.6% |
| Think that mobile phone can carry bacteria | N | 111 | 14 |
| | % | 88.8% | 11.2% |
| Carry mobile phone with patient material | N | 75 | 50 |
| | % | 60.0% | 40.0% |
| Hand wash after mobile phone use in hospital | N | 84 | 41 |
| | % | 67.2% | 32.8% |
| Hand wash before attend the patient | N | 116 | 9 |
| | % | 92.8% | 7.2% |
| Have source of infection | N | 13 | 112 |
| | % | 10.4% | 89.6% |
| Use antibiotics without prescription | N | 7 | 118 |
| | % | 5.6% | 94.4% |
| Indiscriminate or prolonged use of antibiotic | N | 22 | 103 |
| | % | 17.6% | 82.4% |

***Bacterial contamination of mobile phones***

A total of 6 bacterial isolates were obtained from the swabbed phone with an overall bacterial contamination rate of 84%. Among the isolates, Gram-negative bacteria predominated and accounted for 56.8%, with pseudomonas aeruginosa contributing 21.6% and E. coli 20.8% of the swabbed samples. In 16.8% of the swabbed samples, staphylococcus epidermidis was the most common Gram-positive bacterial isolate. Other organisms isolated include klebsiella pneumonia, which accounted for 14.4%, staphylococcus aureus 6.4%, and clostridium spp. 4.0% as shown in table 3. Mobile phone contamination was more common in the age group of 31–41 years (88.9%) and among males (86.1%). Bacterial isolates were found on every mobile phone that healthcare assistants carried as shown in table 4.

***Table 3. Bacterial isolates from mobile phones of Health Care Workers (n=125)***

| Name of the Bacteria | N | % |
|---|---|---|
| **Gram-negative bacteria** | 71 | 56.8 |
| E. coli | 26 | 20.8% |
| Klebsiella pneumonia | 18 | 14.4% |
| Pseudomonas aeruginosa | 27 | 21.6% |
| **Gram-positive bacteria** | 34 | 27.2% |
| Staphylococcus aureus | 8 | 6.4% |
| Staphylococcus epidermidis | 21 | 16.8% |
| Clostridium spp | 5 | 4.0% |
| **NO growth** | 20 | 16.0% |
| Total | 125 | 100.0% |

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***Table 4. Effects of demographic variables on bacterial contamination of health care workers' mobile phones***

| Variables | Class | | Organism | | Total | $x^2$ | *p* |
|---|---|---|---|---|---|---|---|
| | | | No contamination | Contamination | | | |
| Gender | Female | N | 15 | 74 | 89 | 0.168 | 0.682 |
| | | % | 16.9% | 83.1% | 100% | | |
| | Male | N | 5 | 31 | 36 | | |
| | | % | 13.9% | 86.1% | 100% | | |
| Occupation | Doctor | N | 6 | 39 | 45 | 6.493 | 0.090 |
| | | % | 13.3% | 86.7 | 100% | | |
| | Nurse | N | 11 | 30 | 41 | | |
| | | % | 26.8% | 73.2% | 100% | | |
| | Technician | N | 3 | 25 | 28 | | |
| | | % | 10.7% | 89.3% | 100% | | |
| | Health care assistant | N | 0 | 11 | 11 | | |
| | | % | 0.0% | 100% | 100% | | |
| Age | 19-30 | N | 11 | 46 | 57 | 1.295 | 0.523 |
| | | % | 19.3% | 80.7% | 100% | | |
| | 31-41 | N | 5 | 40 | 45 | | |
| | | % | 11.1% | 88.9% | 100% | | |
| | > 41 | N | 4 | 19 | 23 | | |
| | | % | 17.4% | 82.6% | 100% | | |
| Education | Bachelor's | N | 8 | 40 | 48 | 0.686 | 0.953 |
| | | % | 16.7% | 83.3% | 100% | | |
| | Higher Diploma | N | 6 | 34 | 40 | | |
| | | % | 15.0% | 85.0% | 100% | | |
| | Intermediate Diploma | N | 6 | 28 | 34 | | |
| | | % | 17.6% | 82.4% | 100% | | |
| | Master | N | 0 | 1 | 1 | | |
| | | % | 0.0% | 100% | 100% | | |
| | Doctor | N | 0 | 2 | 2 | | |
| | | % | 0.0% | 100% | 100% | | |
| Number of mobiles | One | N | 17 | 86 | 103 | 0.111 | 0.739 |
| | | % | 16.5% | 83.5% | 100.0% | | |
| | Two | N | 3 | 19 | 22 | | |
| | | % | 13.6% | 86.4% | 100.0% | | |

Regarding the usage of mobile phones and hygiene practices (table 5), the highest proportion of mobile phone contamination was observed amongst healthcare workers who frequently cleaned their phones, with a contamination rate of 86.4%. The predominant bacteria in this group were pseudomonas aeruginosa which was isolated at a contamination rate of 26.3%. Remarkably, the bacterial contamination prevalence of mobile phones owned by those healthcare workers with a known source of infection was 92.3%. Furthermore, bacterial contamination was found in 85.7% of people who used antibiotics without a prescription, in 77.3% of participants who used antibiotics indiscriminately or for an extended period.

***Variables linked to bacterial contamination of mobile phones***

In this study, there were no significant correlations found between mobile phone contamination and different variables (gender, age, occupation, phone usage, and hygiene practices) as shown in table 4 and 5.

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***Table 5. Variable linked to bacterial contamination of health care workers' mobile phones***

| Variables | Class | | Organism | | Total | $x^2$ | $p$ |
|---|---|---|---|---|---|---|---|
| | | | No contamination | Contamination | | | |
| Mobile cover | 0 | N | 5 | 33 | 38 | 0.328 | 0.567 |
| | | % | 13.2% | 86.8% | 100% | | |
| | 1 | N | 15 | 72 | 87 | | |
| | | % | 17.2% | 82.8% | 100% | | |
| Use in hospital | 0 | N | 1 | 14 | 15 | 1.105 | 0.293 |
| | | % | 6.7% | 93.3% | 100% | | |
| | 1 | N | 19 | 91 | 110 | | |
| | | % | 17.3% | 82.7% | 100% | | |
| Same mobile at home | 0 | N | 2 | 4 | 6 | 1.409 | 0.235 |
| | | % | 33.3% | 66.7% | 100% | | |
| | 1 | N | 18 | 101 | 119 | | |
| | | % | 15.1% | 84.9% | 100% | | |
| Share with colleagues | 0 | N | 15 | 78 | 93 | 0.005 | 0.947 |
| | | % | 16.1% | 83.9% | 100% | | |
| | 1 | N | 5 | 27 | 32 | | |
| | | % | 15.6% | 84.4% | 100% | | |
| Share with family member | 0 | N | 10 | 62 | 72 | 0.563 | 0.453 |
| | | % | 13.9% | 86.1% | 100% | | |
| | 1 | N | 10 | 43 | 53 | | |
| | | % | 18.9% | 81.1% | 100% | | |
| Use mobile while attend patient | 0 | N | 5 | 29 | 34 | 0.58 | 0.809 |
| | | % | 14.7% | 85.3% | 100% | | |
| | 1 | N | 15 | 76 | 91 | | |
| | | % | 16.5% | 83.5% | 100% | | |
| Regular cleaning | 0 | N | 8 | 29 | 37 | 1.236 | 0.266 |
| | | % | 21.6% | 78.4% | 100% | | |
| | 1 | N | 12 | 76 | 88 | | |
| | | % | 13.6% | 86.4% | 1000% | | |
| Think of bacteria | 0 | N | 4 | 10 | 14 | 1.854 | 0.173 |
| | | % | 28.6% | 71.4% | 100% | | |
| | 1 | N | 16 | 95 | 111 | | |
| | | % | 14.4% | 85.6% | 100% | | |
| Carry mobile with patient material | 0 | N | 8 | 42 | 50 | | |
| | | % | 16.0% | 84.0% | 100% | | |
| | 1 | N | 12 | 63 | 75 | | |
| | | % | 16.0% | 84.0% | 100% | | |
| Hand wash after mobile use | 0 | N | 3 | 38 | 41 | 3.423 | 0.064 |
| | | % | 7.3% | 92.7% | 100% | | |
| | 1 | N | 17 | 67 | 84 | | |
| | | % | 20.2% | 79.8% | 100% | | |
| Hand wash before attend patient | 0 | N | 1 | 8 | 9 | 0.172 | 0.678 |
| | | % | 11.1% | 88.9% | 100% | | |
| | 1 | N | 19 | 97 | 116 | | |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | % | 16.4% | 83.6% | 100% | | |
| Have source of infection | 0 | N | 19 | 93 | 112 | 0.745 | 0.388 |
| | | % | 17.0% | 83.0% | 100% | | |
| | 1 | N | 1 | 12 | 13 | | |
| | | % | 7.7% | 92.3% | 100% | | |
| Use antibiotics without prescription | 0 | N | 19 | 99 | 118 | 0.016 | 0.899 |
| | | % | 16.1% | 83.9% | 100% | | |
| | 1 | N | 1 | 6 | 7 | | |
| | | % | 14.3% | 85.7% | 100% | | |
| Indiscriminate or prolonged use of antibiotic | 0 | N | 15 | 88 | 103 | 0.899 | 0.343 |
| | | % | 14.6% | 85.4% | 100% | | |
| | 1 | N | 5 | 17 | 22 | | |
| | | % | 22.7% | 77.3% | 100% | | |

***Antibiotic Resistance and Sensitivity pattern of bacterial isolates***

Overall, levofloxacin (98.1%), ciprofloxacin (88.6%), and ceftriaxone (84.8%) shown higher effectiveness against bacterial isolates. Whereas, vancomycin showed limited effectiveness with an activity rate of 55.2% against bacterial isolates, specifically against staphylococcus aureus with only 13% susceptibility. In contrast, the resistance rates for erythromycin and clindamycin were 86.7% and 71.2%, respectively, indicating poorer effectiveness. Resistance to erythromycin was detected in 100% staphylococcus aureus, 93% pseudomonas aeruginosa, 90% Staphylococcus epidermidis, 85% of E coli as indicated in table 6, 7(a), and 7(b). There were no significant associations found between indiscriminate or prolonged use of antibiotic and antibiotic resistance of bacterial isolates from healthcare workers' mobile phones (p value more than 0.05)

***Table 6. Patterns of antibiotic resistance and sensitivity of bacterial isolates from healthcare workers' mobile phones (n = 125)***

| Antibiotics | | Resistance | Sensitivity |
|---|---|---|---|
| Clindamycin | N | 74 | 30 |
| | % | 71.2% | 28.8% |
| Doxycycline | N | 39 | 66 |
| | % | 37.1% | 62.9% |
| Cefixime | N | 38 | 66 |
| | % | 36.5% | 63.5% |
| Augmentin | N | 36 | 69 |
| | % | 34.3% | 65.7% |
| Gentamicin | N | 24 | 81 |
| | % | 22.9% | 77.1% |
| Ciprofloxacin | N | 12 | 93 |
| | % | 11.4% | 88.6% |
| Levofloxacin | N | 2 | 103 |
| | % | 1.9% | 98.1% |
| Ceftriaxone | N | 16 | 89 |
| | % | 15.2% | 84.8% |
| Sulfamethoxazole-Trimethoprim | N | 42 | 63 |
| | % | 40.0% | 60.0% |
| Erythromycin | N | 91 | 14 |
| | % | 86.7% | 13.3% |
| Vancomycin | N | 13 | 16 |
| | % | 44.8% | 55.2% |

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***Table 7. A. Patterns of antibiotic resistance and sensitivity of bacterial isolates from healthcare workers' mobile phones (n = 125)***

| Bacterial isolates | | Clindamycin | | Doxycycline | | Cefixime | | Amoxicillin-Clavulanic Acid | | Gentamicin | | Ciprofloxacin | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **E. coli** | R | 21 | 84% | 12 | 46% | 5 | 19% | 10 | 38% | 2 | 8% | 3 | 12% |
| | S | 4 | 16% | 14 | 54% | 21 | 81% | 16 | 62% | 24 | 92% | 23 | 88% |
| Total | | 25 | 100% | 26 | 100% | 26 | 100% | 26 | 100% | 26 | 100% | 26 | 100% |
| **Klebsiella pneumonia** | R | 13 | 72% | 8 | 44% | 7 | 39% | 5 | 28% | 9 | 50% | 5 | 28% |
| | S | 5 | 28% | 10 | 56% | 11 | 61% | 13 | 72% | 9 | 50% | 13 | 72% |
| Total | | 18 | 100% | 18 | 100% | 18 | 100% | 18 | 100% | 18 | 100% | 18 | 100% |
| **Pseudomonas aeruginosa** | R | 24 | 89% | 14 | 52% | 19 | 70% | 11 | 41% | 11 | 41% | 4 | 15% |
| | S | 3 | 11% | 13 | 48% | 8 | 30% | 16 | 59% | 16 | 59% | 23 | 85% |
| Total | | 27 | 100% | 27 | 100% | 27 | 100% | 27 | 100% | 27 | 100% | 27 | 100% |
| **Staphylococcus aureus** | R | 7 | 88% | 0 | 0% | 2 | 25% | 1 | 13% | 0 | 0% | 0 | 0% |
| | S | 1 | 13% | 8 | 100% | 6 | 75% | 7 | 88% | 8 | 100% | 8 | 100% |
| Total | | 8 | 100% | 8 | 100% | 8 | 100% | 8 | 100% | 8 | 100% | 8 | 100% |
| **Staphylococcus epidermidis** | R | 8 | 38% | 5 | 24% | 5 | 25% | 8 | 38% | 2 | 10% | 0 | 0% |
| | S | 13 | 62% | 16 | 76% | 15 | 75% | 13 | 62% | 19 | 90% | 21 | 100% |
| Total | | 21 | 100% | 21 | 100% | 20 | 100% | 21 | 100% | 21 | 100% | 21 | 100% |
| **Clostridium spp** | R | 1 | 20% | 0 | 0% | 0 | 0% | 1 | 20% | 0 | 0% | 0 | 0% |
| | S | 4 | 80% | 5 | 100% | 5 | 100% | 4 | 80% | 5 | 100% | 5 | 100% |
| Total | | 5 | 100% | 5 | 100% | 5 | 100% | 5 | 100% | 5 | 100% | 5 | 100% |

***Table 7. B. Patterns of antibiotic resistance and sensitivity in bacterial isolates from healthcare workers' mobile phones (n = 125)***

| Bacterial isolates | | Levofloxacin | | Ceftriaxone | | Trimethoprim-Sulfamethoxazole | | Erythromycin | | Vancomycin | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **E. coli** | R | 1 | 4% | 0 | 0% | 3 | 12% | 22 | 85% | 2 | 100% |
| | S | 24 | 96% | 26 | 100% | 23 | 88% | 4 | 15% | 0 | 0% |
| Total | | 25 | 100% | 26 | 100% | 26 | 100% | 26 | 100% | 2 | 100% |
| **Klebsiella pneumonia** | R | 0 | 0% | 5 | 28% | 5 | 28% | 14 | 78% | 1 | 100% |
| | S | 18 | 100% | 13 | 72% | 13 | 72% | 4 | 22% | 0 | 0% |
| Total | | 18 | 100% | 18 | 100% | 18 | 100% | 18 | 100% | 1 | 100% |
| **Pseudomonas aeruginosa** | R | 0 | 0% | 7 | 26% | 17 | 63% | 25 | 93% | 0 | 0% |
| | S | 27 | 100% | 20 | 74% | 10 | 37% | 2 | 7% | 0 | 0% |
| Total | | 27 | 100% | 27 | 100% | 27 | 100% | 27 | 100% | 0 | 0% |
| **Staphylococcus aureus** | R | 0 | 0% | 1 | 13% | 6 | 75% | 8 | 100% | 7 | 88% |
| | S | 8 | 100% | 7 | 88% | 2 | 25% | 0 | 0% | 1 | 13% |
| Total | | 8 | 100% | 8 | 100% | 8 | 100% | 8 | 100% | 8 | 100% |
| **Staphylococcus epidermidis** | R | 0 | 0% | 2 | 10% | 9 | 43% | 19 | 90% | 3 | 20% |
| | S | 21 | 100% | 19 | 90% | 12 | 57% | 2 | 10% | 12 | 80% |
| Total | | 21 | 100% | 21 | 100% | 21 | 100% | 21 | 100% | 15 | 100% |
| **Clostridium spp** | R | 0 | 0% | 1 | 20% | 2 | 40% | 3 | 60% | 0 | 0% |
| | S | 5 | 100% | 4 | 80% | 3 | 60% | 2 | 40% | 3 | 100% |
| Total | | 5 | 100% | 5 | 100% | 5 | 100% | 5 | 100% | 3 | 100% |

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***Patterns of multidrug resistance (MDR) among bacterial isolates***

In the present study, multidrug resistance (MDR) was found in 80% of the bacterial isolates. MDR features were displayed by Staph aureus (100%), Pseudomonas aeurginosa (88.9%), E. coli (84.6%), and Klebsiella pneumonia (83.3%) out of all the bacterial isolates as indicated in table 8. Resistance to seven antibiotics was demonstrated by Pseudomonas aeurginosa, Klebsiella pneumonia, and Staphylococcus epidermidis.

***Table 8. Multiple antibiotic resistance of bacterial isolates from healthcare worker 'mobile phones(n=125)***

| Bacterial isolates | Resistant for 2 drugs | | Resistant for 3 drugs | | Resistant for 4 drugs | | Resistant for 5 drugs | | Resistant for 6 drugs | | Resistant for 7 drugs | | Resistant for 8 drugs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % | n | % | n | % | n | % |
| E. coli (n=26) | 3 | 11.5% | 8 | 30.8 % | 9 | 34.6 % | 0 | 0% | 2 | 7.7% | 0 | 0% | 0 | 0% |
| Staphylococcus epidermis (n=21) | 3 | 14.3% | 2 | 9.5% | 1 | 4.8% | 1 | 4.8% | 3 | 14.3 % | 1 | 4.8% | 1 | 5% |
| Pseudomonas aeurginosa (n=27) | 1 | 3.7% | 3 | 11.1 % | 4 | 14.8 % | 1 | 3.7% | 7 | 25.9 % | 8 | 29.6 % | 0 | 0% |
| Clostridium spp. (n=5) | 2 | 40.0% | 1 | 20.0 % | 0 | 0.0% | 0 | 0% | 0 | 0.0% | 0 | 0.0% | 0 | 0% |
| Klebsiella pneumonia (n=18) | 0 | 0% | 6 | 33.3 % | 2 | 11.1 % | 2 | 11.1 % | 0 | 0.0% | 5 | 27.8 % | 0 | 0% |
| Staphylococcus aureus (n=8) | 0 | 0% | 1 | 12.5 % | 6 | 75.0 % | 1 | 12.5 % | 0 | 0.0% | 0 | 0% | 0 | 0% |
| Total n=105 | 9 | 8.6% | 21 | 20% | 22 | 21% | 5 | 4.8% | 12 | 11.4 % | 14 | 13.3 % | 1 | 0.9% |

## Discussion

The findings of this study have pointed out some key issues in medical professionals regarding their mobile phone use and personal hygiene. While 88.8% of participants knew that mobile phones could contain pathogens, a significant proportion of them used their phones at home (95.2%) and in hospitals (88%) under conditions that could increase the risk of cross-contamination [15]. This behaviour shows quite clearly that the difference is between knowledge and its application and may require more powerful interventions in order to increase adherence to hygienic guidelines. Although high contamination rates were noted, interestingly, only 64% of participants admitted that mobile phones could act as source of bacterial transmission [15]. This disparity suggests a lack of knowledge regarding infection prevention strategies pertaining to personal electronic devices. Even though the protective cover usage prevalence was 69.6%, indicating that participants do take some care, this may not be enough to actually decrease the contamination risk. There should be rigorous hygiene practices because if not cleaned regularly, pathogens can accumulate on these covers [16].

Some of the other worrisome practices in the study were about sharing and usage of the phone. This risk of pathogen transmission is further compounded when the phones are shared with co-workers at 25.6% and family members at 42.4%. Sharing with family members, for which this behaviour was prevalent, is reported by nurses to be highest at 43.9%. This result agrees with the work of Byrd et al. (2019) [17], in which similar trends were realized in healthcare professionals to necessitate the need for targeted hygiene interventions among this group. Moreover, there was a difference in the carrying of mobile phones with patient care supplies, which was 60% for participants, significantly different from technicians and physicians, accounting for 32.1 and 82.2%, respectively. This could be due to the difference in work environments and roles, suggesting that educational programs should be adjusted accordingly [15].

It is, however, comforting to note that a majority of participants had healthy hygiene practices, judging by 70.4% cleaning their phones and 67.2% washing hands after the use of the phone. However, the high

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percentage of 92.8 percent washing hands before patient contact instead of recognizing the phones as a source of contamination is due to the following of the protocols set by the hospitals. This suggests a chance for improved instruction that emphasizes the dangers of using a mobile phone [18].

Our findings from the study showed that 84% of mobile phones were highly contaminated with bacteria, gram-negative bacteria making up 56.8%. The most common organisms isolated were Pseudomonas aeruginosa and Escherichia coli, which constituted 21.6% and 20.8%, respectively. This agrees with previous studies that have indicated how mobile phones can be carriers of harmful bacteria. The presence of different types of pathogens within the mobile device, such as Staphylococcus species and E. coli, indicates the regular necessity of disinfection [19]. Another study, by Karpanen et al. in 2008 [20], showed a higher prevalence of Staphylococcus aureus in their healthcare-associated samples, while in our findings, Staphylococcus epidermidis was the predominant gram-positive isolate at 16.8%. This difference may be due to the different populations studied and the background settings; whereas Karpanen's research was focused on hospital equipment, our study was more concerned with personal mobile devices.

The susceptibility pattern showed that S. aureus revealed a considerable amount of methicillin resistance of around 40% but very good sensitivity, approximately 95%, against vancomycin [21]. In our study, S. aureus were highly resistant to erythromycin (100%) and clindamycin (88%). Staphylococcus epidermidis is a coagulase-negative staphylococcus that is generally of lower virulence, although it also shows multidrug resistance patterns similar to S. aureus.

In our study klebsiella pneumonia showed a resistance to clindamycin and erythromycin (72%, 78%) respectively. The development of extended-spectrum beta-lactamase ESBL-producing strains has raised concern over treatment efficacy in Klebsiella spp. It has been reported that nearly 50% of the Klebsiella isolates obtained from mobile phones were ESBL producers which were resistant to commonly used antibiotics like ampicillin and cephalosporins but sensitive to carbapenems [22]

Specific investigations into C. difficile on mobile phones are lacking, but general findings indicate potentially high contamination rates in the hospital environment where antibiotic usage is considerable. The isolated bacteria in our samples represented a high sensitivity pattern to the most studied antibiotics 80%, 100%, 100%. 80%, 100% to clindamycin, doxycycline, cefixime, Augmentin, gentamicin and vancomycin respectively. This sensitivity profile suggests that these antibiotics could be effective treatment options for infections caused by these specific strains of C. difficile.

The results showed that Pseudomonas aeruginosa was the most common Gram-negative bacterium isolated from regularly cleaned phones at a rate of 26.3% and from those carried with patient-related materials at 30.2%. This shows that even when cleaning practices are in place, some bacteria may persist due to their hard nature and ability to survive on surfaces. Pseudomonas aeruginosa is an environmentally versatile bacterium resistant to many disinfectants and thus is often found contaminating healthcare facilities [23]. It is also important to appreciate that the bacteria Pseudomonas aeruginosa has several intrinsic resistance mechanisms; however, 60% of the mobile phone isolates according to Elhassan et al. (2021) [24], were resistant to ciprofloxacin but remained sensitive to piperacillin-tazobactam and meropenem. The similar sensitivity pattern is observed in a study conducted by Khan et al. (2020) [25]. The researchers found that isolates from mobile phones exhibited similar resistance patterns to those obtained from patients, indicating potential cross-contamination. In another study, their findings revealed alarming levels of multidrug resistance among isolates, with 70% showing resistance to at least three classes of antibiotics [26]. This is similar to our results indicating a multidrug resistant pattern. This highlights the critical need for regular monitoring and stringent infection control measures in healthcare settings.

On the other hand, Escherichia coli was the most isolated bacterium among subjects who reported using antibiotics in a careless or prolonged manner (47.1%) and from phones shared with co-workers (29.6%). The high rate of E. coli isolation in these contexts may be related to the selective pressure that antibiotic misuse has been exerting on this microorganism, increasing its colonization by resistant strains. E. coli is a member of the normal gut flora but can become pathogenic under certain conditions, particularly when transferred to inappropriate sites or when antibiotic resistance develops [27]. The sharing of phones among co-workers further facilitates the transmission of this bacterium, highlighting the need for improved hygiene practices in communal environments. One study carried out in a tertiary care hospital reported that roughly 30% of cell phones had E. coli on them [22]. In the intensive care unit, where hygiene practices may be compromised due to high workload, another study has found that prevalence could be as high as 40% [26]. The finding of E. coli on mobile devices has raised concerns since it may be indicative of nosocomial infection pathways, especially with regard to health personnel using their phones either before or after patient contact. Recent analysis has shown that quite a significant percent of E. coli strains is resistant to the commonly prescribed antibiotics ampicillin (up to 70%), while in ciprofloxacin, resistance is about 20% and nitrofurantoin, 10% [28]. At the same time, carbapenems had the highest susceptibility rate.

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According to the findings, 86.3% of participants who regularly cleaned their phones still had bacterial isolates on them, reflecting the alarmingly high frequency of bacterial contamination on healthcare workers' mobile phones. This therefore suggests that regular cleaning procedures may not be adequate in eradicating the presence of microorganisms, especially in high-contact settings such as hospitals, where the chance of cross-contamination is very high [23]. Hand hygiene alone cannot completely reduce the risk of bacterial transmission from mobile devices to patients, as evidenced by the fact that 83.6% of people who routinely washed their hands before interacting with patients also had contaminated phones [27].

This is further revealed in the appalling rate of 92.3% among those with a source of infection, and the bacterial contamination on the cell phones of health professionals attests to that. Since these mobile devices are widely used where there is increased potential for the transmission of highly infectious pathogens, this statistic serves to underscore how absolutely essential rigid hygiene practices in healthcare settings have become [22]. The proximity to patients, close positioning of phones, and probable cross-contamination in patient-care activities account for the high rate of contamination of mobile phones.

Further, from the data, 85.7% of those who take antibiotics without prescriptions had bacterial contamination in their devices. Because self-medication and antibiotic abuse can lead to bacteria becoming more resistant, this finding raises concern [27]. In recent years, several public health problems related to overuse of antibiotics include a rise in multi-resistant organisms [28]. It is thus essential for medical professionals to follow the prescription and use norms for each antibiotic.

Moreover, the rates of bacterial colonization on the cell phones of 77.3% of the respondents who used antibiotics at irrelevant indications or for prolonged courses were significantly high. Such correlation may imply that inappropriate antibiotic use could affect not only individual health but also broader epidemiological processes in bacterial infections [29]. The correlation of microbial resistance with the abuse of antibiotics requires educating both patients and clinicians on their role in ensuring responsible stewardship of antibiotics.

Levofloxacin, ciprofloxacin, and ceftriaxone were much more potent against bacterial isolates in our study compared to other antibiotics, with susceptibility rates of 98.1%, 88.6%, and 84.8%, respectively. This agrees with previous studies, which have constantly indicated that fluoroquinolones, especially ciprofloxacin and levofloxacin, are usually the most potent agents against a wide variety of bacterial pathogens due to their broad-spectrum activity and ability to efficaciously penetrate tissues. A study by Smith et al. in 2020 [15] on susceptibility rates for levofloxacin against common Gram-negative bacteria also showed similarly high rates and further supports the role of this agent as one of first choice in many clinical settings.

On the contrary, our results indicated that vancomycin exhibited an overall low activity rate of 55.2% against bacterial isolates, hence reflecting its ineffectiveness. Its performance was particularly very poor against Staphylococcus aureus; only 13% susceptibility was noted. In agreement with these findings, results by Johnson et al. (2019) [30], reveal a disturbing trend of reduced susceptibility to vancomycin in their cohort studies on Staphylococcus aureus, indicating the emergence of resistant strains in clinical settings. The limited effectiveness of vancomycin underlines the need for continued monitoring and other therapeutic approaches for infections caused by resistant Staphylococcus species.

Besides, resistance rates to erythromycin and clindamycin reached as high as 86.7% and 71.2%, respectively. These results are in good agreement with observations by Lee et al. 2021 [31] while analysing bacterial strains from various infection sites and stating the increasing tendencies of resistance within macrolides and lincosamides groups. The elevated resistance rates can be indicative of the fact that these antibiotics can no longer constitute a reliable weapon against certain bacteria.

With 80% of the bacterial isolates in this study exhibiting multidrug resistance (MDR), the high prevalence of MDR highlights a serious public health concern. The discovery that Staphylococcus aureus had a 100% MDR rate is consistent with earlier studies showing that the bacteria have strong resistance mechanisms [15]. Global trends of rising antibiotic resistance are also reflected in the high resistance rates in Klebsiella pneumoniae (83.3%), E. coli (84.6%), and Pseudomonas aeruginosa [32].

The resistance of Staphylococcus epidermidis, Klebsiella pneumoniae, and Pseudomonas aeruginosa to seven antibiotics is especially worrisome. This widespread resistance restricts therapeutic options and makes treatment protocols more difficult [33]. The acquisition of resistance genes via horizontal gene transfer, efflux pump overexpression, or biofilm are some possible mechanisms underlying such widespread resistance [33].

## Conclusion

This pioneering study has, therefore, unmasked a significant disconnect between high awareness and poor practice of mobile phone hygiene among health workers, underlining an important area for intervention. The persistence of pathogens such as Pseudomonas aeruginosa and Escherichia coli on devices, even after

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regular cleaning, calls for immediate standardization of disinfection practices relevant to healthcare settings. This study also points out the scary role that mobile phones play in the dissemination of multidrug-resistant organisms and the urgent need to revisit policies on the use of antibiotics, as well as the reinforcement of antibiotic stewardship. Aggressive educational programs and rigorous hygiene strategies can go a long way in minimizing infection risks and cross-contamination in healthcare facilities, thus protecting both patients and healthcare workers from the menace of contaminated mobile devices.

***Conflict of interest***. Nil

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**المستخلص**

يمكن للهواتف المحمولة للعاملين في مجال الرعاية الصحية أن تنقل مجموعة من البكتيريا المسببة للأمراض التي تسبب العدوى المكتسبة في المستشفيات إلى المرضى والمجتمع. أجريت هذه الدراسة لتحديد مدى انتشار التلوث البكتيري للهواتف المحمولة للعاملين في مجال الرعاية الصحية، وتقييم أنواع العزلات البكتيرية وأنماط حساسيتها للمضادات الحيوية ومقاومتها والعوامل التي تساهم في التلوث. أُجريت دراسة مقطعية في مركز الهواري للكلى شملت 125 من العاملين في مجال الرعاية الصحية. جُمعت البيانات الديموغرافية والبيانات المتعلقة بتاريخ استخدام المضادات الحيوية وكذلك سلوك التنظيف للهواتف المحمولة وباستخدام استبيان منظم. تم إجراء اختبار الحساسية لمضادات الميكروبات لجميع عينات المسحات من الهواتف المحمولةالتي تم جمعها. تحليل البيانات باستخدام الإصدار 28 من برنامج SPSS. تم الكشف عن معدلات انتشار الكائنات الدقيقة المقاومة للمضادات الحيوية مع الأنماط المقابلة لقابلية التعرض للمضادات الحيوية. تم عرض النتائج باستخدام الجداول للتوضيح. كان الانتشار الإجمالي للتلوث بالهاتف المحمول 84% من العينات الممسوحة. كانت أكثر العزلات البكتيرية شيوعًا هي الزائفة الزنجارية الزنجارية 21.6% تليها الإشريكية القولونية 20.8%، والمكورات العنقودية فوق الجلدية 16.8%، والكلبسيلا الرئوية 14.4%، والمكورات العنقودية الذهبية 6.4%، والمطثية العنقودية 4%، والمطثية العنقودية الذهبية 4%. كانت معظم العزلات حساسة لليفوفلوكساسين (98.1%) وسيبروفلوكساسين (88.6%) وسيفترياكسون (84.8%). أظهر فانكومايسين فعالية محدودة ضد المكورات العنقودية الذهبية على وجه التحديد مع قابلية 13% فقط. كانت 86.7% و71.2% من العزلات البكتيرية مقاومة للإريثروميسين والكليندامايسين على التوالي. لم يتم العثور على أي علاقة ذات دلالة إحصائية بين التلوث بالهاتف المحمول ومتغيرات مختلفة للمشاركين مثل الجنس والعمر والمهنة واستخدام الهاتف المحمول وممارسات النظافة الصحية. كان معدل الانتشار العام للبكتيريا المقاومة للأدوية المتعددة 80.% تشير هذه الدراسة إلى الدور المخيف الذي تلعبه الهواتف المحمولة في نشر الكائنات الحية المقاومة للأدوية المتعددة والحاجة الملحة لإعادة النظر في السياسات المتعلقة باستخدام المضادات الحيوية، فضلاً عن تعزيز الإشراف على المضادات الحيوية.

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