

Bacterial Carriage and Antimicrobial Susceptibility Among Intensive Care Unit Nursing Staff at Zliten Teaching Hospital, Libya: A 2013 Cross-Sectional Study

Abdalla Muftah Albakosh^{1*}, Mostafa Mohamed Mohamed Ali², Ibrahim Abdallah Egfier³

¹Department of Microbiology and Immunology, Faculty of Medicine, Alasmarya Islamic University, Zliten, Libya

²Department of Biology, Faculty of Science, El-Mergib University, Elkhoms, Libya

³Department of Pharmacology, Faculty of Medicine, Alasmarya Islamic University, Zliten, Libya, Libya

*Corresponding Author: Abdalla Muftah Albakosh

E-mail: a.albakoush@asmarya.edu.ly

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ABSTRACT

Background: Healthcare-associated infections remain a major concern in intensive care units (ICUs). Nursing staff have frequent direct patient contact, and bacterial carriage in the anterior nares and contamination of the hands may contribute to healthcare-associated transmission. **Objective:** To describe bacterial carriage in the anterior nares and bacterial recovery from the hands of ICU nursing staff at Zliten Teaching Hospital, Libya, characterise the antimicrobial susceptibility of recovered isolates, and compare paired hand-culture positivity before and after routine handwashing. **Methods:** A descriptive observational study with paired pre- and post-handwashing hand sampling was conducted during the summer of 2013. Fifty-four specimens were collected from 18 nurses (18 nasal, 18 hand-before-washing, and 18 hand-after-washing). Specimens were cultured aerobically on blood and MacConkey agar. Bacterial identification and antimicrobial susceptibility testing were performed using the BD Phoenix™ 100 Automated Microbiology System. Paired hand-culture positivity was compared using the exact McNemar test. **Results:** Forty of 54 specimens (74.1%) were culture-positive and yielded 47 isolates because seven specimens were polymicrobial. Coagulase-negative staphylococci (CoNS) accounted for 38/47 isolates (80.9%) and *Staphylococcus aureus* for 5/47 (10.6%). Hand-culture positivity was 11/18 (61.1%; 95% CI 38.6–79.7%) before washing and 12/18 (66.7%; 95% CI 43.7–83.7%) after washing (exact McNemar test, $P = 1.000$). Three of five *S. aureus* isolates were classified as methicillin-resistant *S. aureus* (MRSA) based on concordant interpretable oxacillin resistance, cefoxitin resistance, and *mecA* resistance-marker positivity. Four Gram-negative isolates were recovered individually from nasal or post-handwashing specimens. **Conclusion:** Bacterial recovery was dominated by CoNS, and three of five *S. aureus* isolates met the available archived laboratory criteria for MRSA. Hand-culture positivity did not differ significantly before and after routine handwashing in this small, paired sample. These findings provide historical, institution-specific cross-sectional data and support the need for contemporary prospective surveillance using standardised sampling, documented hand-hygiene procedures, and current antimicrobial susceptibility standards.

Keywords: Antimicrobial resistance; Hand hygiene; Intensive care unit; Libya; MRSA; Nursing staff

Introduction

Healthcare-associated infections (HAIs) remain a major patient-safety problem and contribute to morbidity, mortality, prolonged hospitalisation, healthcare costs, and antimicrobial resistance (AMR). Intensive care units (ICUs) are particularly vulnerable because critically ill patients frequently require invasive devices, prolonged care, and broad-spectrum antimicrobial therapy. Recent global and African evidence continues to show a substantial HAI and AMR burden, while the World Health Organization (WHO) identifies effective infection prevention and control (IPC) and quality-assured surveillance as central components of patient safety and AMR containment [1-6].

Healthcare workers can acquire or transiently carry microorganisms through repeated contact with patients, devices, and the clinical environment. The anterior nares are an established reservoir for *Staphylococcus aureus*, whereas the hands are a major route for transient microbial contamination and cross-transmission. Methicillin-resistant *S. aureus* (MRSA) carriage among healthcare workers has been documented internationally and in recent systematic reviews, with nursing staff among occupational groups in whom carriage is frequently reported [7-10]. Hand hygiene remains a core IPC measure, although microbiological effectiveness depends on the product used, application time, technique, and coverage of hand surfaces [11-13].

Coagulase-negative staphylococci (CoNS) are common members of the skin and mucosal microbiota and are therefore expected to be frequently recovered in carriage studies. Their presence on screening cultures should not be equated with infection. Nevertheless, CoNS are clinically important opportunistic pathogens, particularly in patients with intravascular or other implanted devices, and healthcare-associated isolates often show substantial antimicrobial resistance [14,15].

Evidence from Libya remains comparatively limited. Earlier studies documented MRSA among healthcare workers and hospital isolates in Tripoli and Benghazi [16,17], and reviews of Libyan AMR data have highlighted persistent surveillance gaps and substantial resistance among clinically important bacteria [18-20]. However, published Libyan data combining nasal bacterial carriage, paired hand cultures obtained before and after routine handwashing, and antimicrobial susceptibility findings within the same ICU nursing cohort remain scarce.

The present study reports institution-specific data collected from ICU nursing staff at Zliten Teaching Hospital in 2013. It aimed to describe bacterial recovery from nasal and hand specimens, characterise the available antimicrobial susceptibility profiles of the recovered isolates, and compare paired hand-culture positivity before and after routine handwashing. The dataset is small and historical, so it cannot estimate current carriage or resistance in Libyan ICUs. Its value lies instead in documenting an earlier local pattern that can help frame and design contemporary surveillance.



MATERIALS AND METHODS

Study Design and Setting

This was a descriptive observational cross-sectional study with paired pre- and post-handwashing hand sampling, conducted in the ICU of Zliten Teaching Hospital, Libya, during the summer of 2013. Hand specimens were collected from the same 18 nurses before and after routine handwashing, producing paired observations. Nasal specimens were collected once from the same participants. Reporting was guided by relevant recommendations of the STROBE statement for observational studies [21].

Participants

Eighteen ICU nurses providing direct patient care participated in the study. The group comprised 16 women and two men, aged 24–53 years. Participation was voluntary and informed consent was obtained before specimen collection. No additional exclusion criteria were documented in the available historical study records.

Handwashing Procedure

Participants washed their hands with soap and running water according to routine practice in the ICU at the time of the study. The exact duration, sequence of steps, drying method, and interval between handwashing and post-washing sampling were not documented in the available historical records. WHO hand-hygiene guidance is cited as background and should not be interpreted as the protocol used in this study [11].

Specimen Collection and Culture

A total of 54 specimens were collected: 18 nasal swabs, 18 hand swabs before handwashing, and 18 hand swabs after handwashing. Sterile cotton swabs pre-moistened with sterile normal saline were used for specimen collection. A single swab was used to sample both anterior nares, and the palms of both hands were sampled for the hand specimens. Samples were transported to the microbiology laboratory and inoculated within three hours of collection. Specimens were cultured on blood agar and MacConkey agar and incubated aerobically at 37 °C for 24 hours.

Bacterial Identification

Preliminary bacterial identification was performed using Gram staining and conventional biochemical tests. Confirmatory identification and antimicrobial susceptibility testing were performed using the BD Phoenix™ 100 Automated Microbiology System (Becton Dickinson



Biosciences, Sparks, MD, USA) with the panel configurations available in the laboratory at the time, according to the manufacturer's instructions.

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility categories were taken from archived BD Phoenix™ records. For the five *S. aureus* isolates, oxacillin results were available for all isolates. Cefoxitin susceptibility and the *mecA* resistance marker were interpretable for three isolates; all three showed concordant oxacillin resistance, cefoxitin resistance, and *mecA* resistance-marker positivity and were classified as MRSA. The remaining two isolates had no interpretable cefoxitin or *mecA* result recorded. The exact Clinical and Laboratory Standards Institute (CLSI) edition used by the laboratory in 2013 could not be verified. Archived susceptibility categories are therefore reported as generated by the instrument and were not retrospectively reinterpreted using current breakpoints. No confirmatory extended-spectrum β -lactamase (ESBL) result was available for the Gram-negative isolates; no Gram-negative isolate was consequently classified as ESBL-positive or multidrug-resistant on the basis of the available historical records.

Statistical Analysis

Data were analysed using SPSS version 20.0 (IBM Corp., Armonk, NY, USA). Categorical data were summarised using frequencies and percentages. Wilson score 95% confidence intervals were calculated for the principal participant- or specimen-level proportions. Because hand-culture results before and after handwashing were paired observations from the same participants, the difference in overall culture positivity was assessed using the exact McNemar test, with a two-sided significance level of 0.05. Antimicrobial susceptibility findings were analysed descriptively because of the small number of isolates.

Ethics Statement

At the time of the study in 2013, Zliten Teaching Hospital did not have an established institutional research ethics committee, so formal ethics approval and an approval number were not available. Before specimen collection, participants were informed about the study and gave informed consent. Participation was voluntary, and study data were anonymised and kept confidential. This lack of formal independent ethics review is reported openly because it reflects the institutional circumstances in which the study was carried out.

Results

Participant Characteristics

The study included 18 ICU nurses: 16 women (88.9%) and two men (11.1%). Participants were aged 24–53 years.

Bacterial Recovery

Of the 54 specimens, 40 (74.1%; 95% CI 61.1–83.9%) were culture-positive and 14 (25.9%) showed no growth. The 40 positive specimens yielded 47 bacterial isolates because seven specimens were polymicrobial: five nasal specimens and two post-handwashing specimens each yielded two organisms. CoNS predominated, accounting for 38/47 isolates (80.9%), followed by *S. aureus* (5/47, 10.6%). One isolate each of *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* was recovered from post-handwashing specimens, and one isolate each of *Pseudomonas pseudoalcaligenes* and *Klebsiella aerogenes* (reported as *Enterobacter aerogenes* in the historical laboratory record) was recovered from nasal specimens [22].

Species-level Gram-negative results for the hand-before-washing group were incomplete in the archived records and are therefore reported as not available rather than as confirmed negative findings.

Table 1. Distribution of bacterial recovery by specimen category. Isolate totals exceed positive-specimen totals in the nasal and post-handwashing groups because some specimens were polymicrobial. *NA, species-level Gram-negative data were not available in the archived hand-before-washing records. †Reported as *Enterobacter aerogenes* in the historical laboratory record; the species is currently classified as *Klebsiella aerogenes* [22].

Organism / outcome	Nasal	Hands before washing	Hands after washing	Total isolates
CoNS	17	10	11	38 (80.9%)
<i>Staphylococcus aureus</i>	3	1	1	5 (10.6%)
<i>Pseudomonas aeruginosa</i>	0	NA*	1	1 (2.1%)
<i>Pseudomonas pseudoalcaligenes</i>	1	NA*	0	1 (2.1%)
<i>Klebsiella pneumoniae</i>	0	NA*	1	1 (2.1%)
<i>Klebsiella aerogenes</i> †	1	NA*	0	1 (2.1%)
Positive specimens	17/18	11/18	12/18	40/54
No growth	1/18	7/18	6/18	14/54
Number of isolates	22	11	14	47

Paired Hand-Culture Positivity Before and After Handwashing

Hand-culture positivity was 11/18 (61.1%; 95% CI 38.6–79.7%) before washing and 12/18 (66.7%; 95% CI 43.7–83.7%) after washing. Among the 18 paired observations, nine were positive at both time points, four were negative at both time points, two changed from positive to negative, and three changed from negative to positive. The exact McNemar test showed no evidence of a difference in culture positivity between the paired pre- and post-handwashing specimens ($P = 1.000$).

Antimicrobial Susceptibility of Staphylococcus aureus

Three of the five *S. aureus* isolates were classified as MRSA based on concordant interpretable oxacillin resistance, ceftazidime resistance, and *mecA* resistance-marker positivity. Oxacillin results were available for all five isolates: three were resistant and two were susceptible. Ceftazidime and *mecA* results were interpretable for three isolates; all three were ceftazidime-resistant and *mecA*-positive, while two isolates had no interpretable ceftazidime or *mecA* result recorded. Two of five isolates were erythromycin-resistant, one was clindamycin-resistant, four were trimethoprim-sulfamethoxazole-resistant, and one was ciprofloxacin-intermediate. Four isolates were categorised as vancomycin-susceptible and one as vancomycin-intermediate in the archived BD Phoenix™ record; no vancomycin-resistant isolate was recorded.

Table 2. Archived BD Phoenix™ antimicrobial susceptibility categories and *mecA* resistance-marker results for *Staphylococcus aureus* isolates ($n = 5$). *mecA* is a resistance marker rather than an antimicrobial susceptibility result.

Antimicrobial / marker	N interpretable	Susceptible / negative	Intermediate	Resistant / positive
Oxacillin	5	2/5 (40%)	0/5 (0%)	3/5 (60%)
Ceftazidime	3 (2 no result)	0/3 (0%)	0/3 (0%)	3/3 (100%)
Vancomycin	5	4/5 (80%)	1/5 (20%)	0/5 (0%)
Erythromycin	5	3/5 (60%)	0/5 (0%)	2/5 (40%)
Clindamycin	5	4/5 (80%)	0/5 (0%)	1/5 (20%)
Trimethoprim-sulfamethoxazole	5	1/5 (20%)	0/5 (0%)	4/5 (80%)
Ciprofloxacin	5	4/5 (80%)	1/5 (20%)	0/5 (0%)
<i>mecA</i> resistance marker	3 (2 no result)	0/3 negative	—	3/3 positive

Gram-Negative Isolates

Four Gram-negative organisms were recovered, each represented by a single isolate: *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* from post-handwashing specimens, and *Pseudomonas pseudoalcaligenes* and *Klebsiella aerogenes* (reported historically as *Enterobacter aerogenes*) from

nasal specimens [22]. Detailed archived susceptibility categories were not retained in the final analysis because the exact 2013 interpretive standard could not be verified and some organism-antimicrobial combinations may not have had clinically applicable breakpoints. No Gram-negative isolate was designated ESBL-positive or multidrug-resistant on the basis of these incomplete historical records.

Discussion

This study provides a historical description of bacterial recovery from nasal and hand specimens collected from 18 ICU nurses at Zliten Teaching Hospital in 2013. CoNS predominated among the 47 recovered isolates, five isolates were *S. aureus*, and three of those five *S. aureus* isolates met the available archived laboratory criteria for MRSA. Four Gram-negative organisms were recovered individually. In the paired analysis, hand-culture positivity was similar before and after routine handwashing, with no statistically significant difference.

The predominance of CoNS is consistent with their role as common constituents of normal skin and mucosal microbiota [14,15]. Their frequent recovery should therefore be interpreted primarily as carriage or contamination rather than infection. This distinction is important in an ICU setting because CoNS can become clinically significant opportunistic pathogens in patients with invasive devices, whereas screening cultures from healthy staff cannot establish transmission or disease [14,15].

The recovery of *S. aureus*, including three isolates classified as MRSA on the basis of concordant interpretable oxacillin resistance, cefoxitin resistance, and *mecA* resistance-marker positivity, is of greater infection-control interest. MRSA carriage among healthcare workers has been reported across different regions, although estimates vary according to population, setting, sampling site, laboratory method, and outbreak status [7-10]. In Libya, Ahmed et al. documented nasal MRSA carriage among healthcare workers in Tripoli hospitals, while Buzaid et al. reported MRSA among clinical *S. aureus* isolates in a Benghazi tertiary hospital [16,17]. These studies show that MRSA was already present in Libyan healthcare settings around the period of the present study. Direct numerical comparison is inappropriate, however, because the present finding is based on only five *S. aureus* isolates and is not a participant-level MRSA prevalence estimate.

One *S. aureus* isolate was categorised as vancomycin-intermediate in the archived BD Phoenix™ record. This finding requires caution. The original MIC value was not available in the records used for this analysis, the exact CLSI edition applied in 2013 could not be verified, and no reference-method confirmation was documented. The result should therefore be regarded as a historical instrument-generated category rather than confirmation of vancomycin-intermediate *S. aureus*. Earlier Libyan surveillance up to 2011 did not identify confirmed vancomycin-intermediate or vancomycin-resistant *S. aureus* using standard methods [18].

The four Gram-negative isolates cannot support organism-specific prevalence estimates or resistance comparisons because each species was represented by only one isolate. In addition, the exact historical interpretive standard could not be reconstructed and no confirmatory ESBL result was available. Detailed archived S/I/R categories were therefore excluded from the final analysis to avoid

overinterpretation. The study can support reporting which Gram-negative organisms were recovered, but it cannot reliably establish contemporary susceptibility, multidrug-resistant status, or specific resistance mechanisms. This conservative approach is consistent with modern surveillance principles that emphasise standardised AST interpretation and quality-assured data [4,5].

The paired handwashing result also requires careful interpretation. Culture positivity was 61.1% before washing and 66.7% after washing, with no evidence of a paired difference. This does not demonstrate that handwashing is ineffective. Hand hygiene is an established IPC intervention, and systematic reviews show that appropriate hand-hygiene techniques reduce microbial burden, although effectiveness varies with technique, product, application time, and adherence [11-13]. In the present study, the washing duration, detailed technique, drying method, and timing of post-washing sampling were not documented. Moreover, the outcome was qualitative culture positivity rather than quantitative bacterial burden. A specimen may remain culture-positive despite a meaningful reduction in bacterial count. The finding is therefore best interpreted as showing no detectable change in culture positivity under the recorded routine conditions, rather than as an evaluation of hand-hygiene efficacy.

The main value of this study is the local historical record it provides. Libya remains underrepresented in standardised AMR and healthcare-worker carriage datasets despite evidence of substantial resistance in national studies and reviews [18-20]. Few Libyan reports combine nasal sampling, paired hand sampling, and susceptibility data from the same ICU nursing group. The 2013 findings do not represent current practice, but they document an earlier institutional pattern and provide a practical reference for designing new surveillance using standardised sampling, current susceptibility criteria, and quality-assured laboratory methods. This is consistent with WHO surveillance guidance, which stresses comparable methods and longitudinal data for monitoring change over time [4,5].

This study has important limitations. It involved one ICU and only 18 nurses, so the estimates are imprecise and should not be generalised to other hospitals. The data were collected in 2013 and do not describe current epidemiology. Some procedural details were not preserved in the historical records, including the full handwashing protocol and the exact CLSI edition used for susceptibility interpretation. Species-level Gram-negative records were incomplete for the pre-handwashing samples, confirmatory ESBL testing and molecular typing were not documented, and the single vancomycin-intermediate *S. aureus* result was not confirmed by a reference method. The handwashing comparison measured culture positivity rather than bacterial load. Formal independent ethics review was also not available at the hospital at the time, although participation was voluntary and informed consent was obtained. These limitations restrict the conclusions that can be drawn, but they do not remove the descriptive value of the dataset as a clearly dated institutional record. The findings should therefore be used as historical context and as a basis for designing better, prospective studies rather than as evidence of current prevalence, transmission, or hand-hygiene effectiveness.

Conclusion

In this 2013 cohort of 18 ICU nurses, CoNS accounted for most bacteria recovered from nasal and hand specimens, and three of five *S. aureus* isolates met the available archived laboratory criteria for



MRSA. Hand-culture positivity was similar before and after routine handwashing, but the small sample and incomplete handwashing records do not allow firm conclusions about hand-hygiene effectiveness. Four Gram-negative organisms were recovered individually, and the available historical susceptibility records were not sufficient for broader resistance conclusions. The study therefore provides a dated, institution-specific description rather than a measure of current prevalence. Its main value is as a local reference point for future prospective surveillance using standardised sampling, current susceptibility criteria, and complete microbiological documentation.

Conflict of Interest

The authors declare that they have no conflict of interest.

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