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Original Article

Evaluation of bacterial pathogens and their antibiotic resistance on surfaces in the Mohammed V hospital, Al-Hoceima, Morocco

Mostapha Abourrich[1], Nadira Mourabit[2], Rachida El Barghmi[5], Samia Boussa[3], Mohammed Ghalit[4], Hossain El Ouarghi[5]

[1] Environmental Health and Hospital Hygiene Department, Provincial Health Delegation of Al-Hoceima, Morocco
[2] Laboratory of Research and Development in Engineering Sciences Team, Faculty of Sciences and Techniques of Al-Hoceima, Abdelmalek Essaadi University, Morocco
[3] Higher Institute of Nursing Professions and Health Techniques, Marrakech, Morocco
[4] Laboratory of Applied Chemistry and Environment, Faculty of Sciences, University Mohamed First, Oujda, Morocco
[5] Research Team of Water and Environment Management, Laboratory of Applied Sciences, National School of Applied Sciences Al-Hoceima, Abdelmalek Essaadi University, Morocco

Abstract

Introduction: The hospital environment is an important source of nosocomial infections. Surfaces in the hospital facilities may be considered as microbial reservoirs that can cause patient contamination. This study aimed to evaluate the microbiological quality of surfaces and equipment in the Mohammed V Hospital, located in Al-Hoceima, Morocco.

Methodology: A total of 360 samples of surfaces were collected by swabbing from 5 service departments (intensive care unit (ICU), maternity, neonatology, operating room, and pediatric) over a period of 1 year (January–December 2021). The samples were analyzed at the provincial public health laboratory of Al-Hoceima. Isolation and identification of bacteria were performed according to conventional bacteriology methods.

Results: The results indicated that 34.4% (124/360) samples were contaminated. The ICU was the most contaminated service and the frequency of contaminated samples was 50%. The most contaminated sampling sites were soap for hand washing (27.4%), trolleys (25.8%), and sinks (22.6%). Gram-positive bacteria represented 51.6% of the contaminants. The most isolated bacteria were *Staphylococcus aureus* (50%), followed by *Klebsiella pneumoniae* (23.5%), and *Pseudomonas aeruginosa* (12.4%). Extended spectrum beta lactamase-producing Enterobacteriaceae represented 31.7% of the contaminants. Methicillin-resistant *Staphylococcus aureus* (MRSA) accounted for 17.6% of the contaminants.

Conclusions: This study provided important data that can guide the nosocomial infection control committee to manage the risks related to contaminated hospital surfaces through the establishment of an adequate risk analysis strategy.

Key words: hospital; bacterial resistance; nosocomial infections; surfaces.

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Introduction

Nosocomial infections (NI), also known as hospital infections, are hospital-acquired infections that occur during hospitalization, and generally occur 48 hours after admission [1]. NI are considered to be a major cause of morbidity and mortality for hospitalized patients [2]. According to a prevalence survey by the World Health Organization (WHO), an average of 8.7% of hospitalized patients develop NI. At any point of time, more than 1.4 million people worldwide suffer from infectious complications acquired in the hospital [3]. The prevalence of NI in Morocco was estimated at 4.1% in provincial hospitals, 7.7% in regional hospitals, and between 9.5% and 11.5% in university hospital centers [4].

The main bacteria responsible for NI were reported to be *Acinetobacter*, *Escherichia coli* (*E. coli*), *Klebsiella*, methicillin-resistant *Staphylococcus aureus* (MRSA), *Pseudomonas aeruginosa*, and *Enterococcus* [5]. These bacteria have been frequently identified in the surgery, intensive care unit (ICU), obstetrics gynecology, and severe burns unit departments [6–8].

In general, NI can be of endogenous or exogenous origin. Infection may be caused by the patient's flora; or may result from contamination by other patients, staff, or the hospital environment (surfaces, water, air, linen, food, medical devices, and waste) [8]. According to WHO, many types of microorganisms survive well in

water, moist areas, occasionally in sterile products or disinfectants, in equipment and supplies used for care, in food, and in fine dust and droplet nuclei generated by coughing or speaking [3]. Hospital environmental contamination is considered to be an important factor for the development of NI [9] and surfaces may be considered as reservoirs of patient contamination, in particular due to the presence of multi-drug resistant (MDR) bacteria [9]. Several epidemiologic studies showed that the risk of acquiring MRSA, vancomycin-resistant enterococcus (VRE), *Clostridium difficile* (*C. difficile*), MDR *Acinetobacter*, and *Pseudomonas* from contaminated environmental surfaces, was two-fold higher for patients admitted to rooms previously occupied by individuals infected or colonized with these organisms [10]. Therefore, microbiological monitoring of the environment of healthcare facilities is an essential measure to reduce the environmental risk [11].

This study aimed to evaluate the microbiological quality of surfaces and equipment in 5 service departments (ICU, maternity, neonatology, surgery, and pediatric) at the Mohammed V Hospital in Al-Hoceima, Morocco.

Methodology

This was a prospective study carried out between January and December 2021 at the Mohammed V Hospital in Al-Hoceima, Morocco.

Sample collection

Samples were taken from different surfaces in the following service departments: ICU, maternity, neonatology, surgery, and pediatric surgery. The choice of sampling sites was made in agreement with clinicians and hospital hygiene managers based on the public health circular No 230 DHSA/22 and the guidelines of the hospital committee for NI control [12]. The most critical and representative sites in each service were targeted.

Sampling technique

A sampling plan was pre-established by the manual of the National Institute of Hygiene (INH2015) [13] to avoid sample contamination. The main target sampling points were sites that were mostly used in the hospital services (bed, table, trolleys, sinks, taps, and soaps for hand washing).

Cotton swabs premoistened in sterile distilled water were used for sampling surfaces. A surface area of 25 cm^2 was swabbed using the method of repeated striations in two zigzag directions according to the ISO/DIS 14698-1 standard [14]. Sampling of each site was repeated 3 times. The collected samples were kept in sterile water and immediately transported on ice to the public health laboratory of the delegation of the Health Ministry in Al-Hoceima. A total of 360 samples collected from surfaces was included in this study (Supplementary Table 1).

Table 1. Distribution of positive surface samples by service department.

Service	n (%)
Intensive care unit	62/124 (50%)
Pediatric surgery	28/124 (22.6%)
Surgery	16/124 (12.9%)
Neonatology	12/124 (9.7%)
Maternity	4/124 (3.2%)
Operating room	2/124 (1.6%)

Isolation and identification

Bacteria were identified based on conventional bacteriology methods. The preliminary identification tests were based on colony aspect and microscopic observation after Gram staining for all the strains isolated. Lactose fermentation and oxidase activity were tested on Mac Conkey agar (bacilli), mannitol fermentation, catalase, coagulase and DNase activity on Chapman's medium (cocci). Catalase test and bile esculin agar (BEA) test were performed for *Streptococcus*. Motility of the isolated bacteria were checked on cetrimide.

The identification was carried out by analytical profile index (API) galleries (API 20E® and API 20NE®; bioMérieux, Marcy-l'Étoile, France)

Antibiogram of isolated bacteria

Antibiotic resistance of the isolated bacteria was determined by the disk diffusion method on Mueller-Hinton (MH) agar plates (Bio-Rad, Marnes-la-Coquette, France). Analysis and interpretation of susceptibility of the strains were based on the recommendations of the Antimicrobial Susceptibility Testing Committee of the Société Française de Microbiology and the European Committee on Antimicrobial Susceptibility Testing 2019 [15].

Statistical analysis

Data were analyzed using the SPSS software version 25 (IBM Corp, Armonk, NY, USA) and correlations analysis were carried out by the Pearson test.

Results

Distribution of sample positivity rate

A total of 124 samples were positive and the

positivity rate was 34.4%. The ICU was the most contaminated service with a frequency of 50% (62/124) (Table 1).

The most contaminated sampling sites were soap for hand washing (27.4%), trolleys (25.8%), and sinks (22.6%) (Table 2). The taps, sinks, and tables were more contaminated in the ICU (85.7%, 71.4%, and 50%, respectively). Beds, trolleys, and tables were more contaminated in the surgical service (25%, 15.6%, and 12.5%, respectively) (Table 3).

Distribution of isolated bacteria

Gram-positive bacteria represented 51.6% (64/124) and Gram-negative bacteria accounted for 48.3% (60/124) of the positive samples. Extended-spectrum beta-lactamase (ESBL)-producing Enterobacteriaceae accounted for 31% (13/42) while methicillin-resistant *Staphylococcus aureus* (MRSA) accounted for 17.6% (11/62) of the samples. The most isolated bacteria were *S. aureus* (50%), followed by *K. pneumoniae* (23.5%), *P. aeruginosa* (12%), *E. coli* (10.4%), *A. baumannii* (2.4%), and *Enterococcus* (1.6%).

P. aeruginosa and *A. baumannii* were isolated only from the ICU samples. *E. coli* and *S. aureus* were primarily found in the surgery department (46% and 42%, respectively; Table 4).

P. aeruginosa and *A. baumannii* were mainly isolated from the sinks with frequencies of 74% (11/15) and 66.6% (2/3), respectively; while the *S. aureus* and *E. coli* were identified in trolleys with frequencies of 42% (26/62) and 38.4% (5/13), respectively (Table 5).

The distributions of all the types of bacteria by sampling sites and service departments are represented in Supplementary Tables 2–7.

Table 2. Distribution of positive surface samples by sites.

Sites	n (%)
Trolleys	32/124 (25.8%)
Sinks	28/124 (22.6%)
Soap for hand washing	34/124 (27.4%)
Bed	8 /124 (6.5%)
Taps	14/124 (11.2%)
Tables	8 /124 (6.5%)

Antimicrobial susceptibility profile

ESBL-producing Enterobacteriaceae represented 31% (13/42) of the isolated bacteria. ESBLs were mainly found in the surgery department (38.4%) and ICU (30.7%) (Supplementary Table 8). ESBLs were mainly identified in sinks, trolleys, and taps (38.4%, 23%, and 15.3%, respectively) (Supplementary Table 8).

MRSAs accounted for 17.6% (11/62), and were mainly found in the surgery department (36.3%), followed by the ICU (27.2%) (Supplementary Table 8). MRSAs were mainly detected in sinks (36.3%), followed by trolleys (18.1%) (Supplementary Table 9).

The distribution of these resistant strains by service department and sampling sites is represented in Supplementary Tables 10 and 11.

Correlation

Correlation analysis showed that surgery and pediatric surgery clustered together and were positively correlated with beds (Supplementary Figure 1). The pathogens isolated from the ICU were unique compared to other service departments (Supplementary Figure 2).

The bacteria isolated from trolleys and tables

Table 3. Distribution of positive samples by sites and service departments.

Variables % (n)	Trolleys	Sinks	Soap for hand washing	Beds	Taps	Tables
ICU (62)	25% (08/32)	71.4% (20/28)	44.1% (15/34)	37.5% (03/8)	85.7% (12/14)	50% (04/8)
Pediatric surgery (28)	37.5% (12/32)	7.1% (02/28)	23.5% (08/34)	25% (02/8)	7.1% (01/14)	37.5% (03/8)
Surgery (16)	15.6% (05/32)	10.7% (03/28)	11.8% (O4/34)	25% (02/8)	7.1% (01/14)	12.5% (01/8)
Neonatology (12)	18.7% (06/32)	3.6% (01/28)	11.8% (04/34)	12.5% (01/8)	0%	0%
Maternity (4)	3.1% (01/32)	3.6% (01/28)	5.9% (02/34)	0%	0%	0%
Operating room (2)	0%	3.6% (1/28)	2.9% (1/34)	0%	0%	0%
Total	32	28	34	8	14	8

ICU: intensive care unit.

Table 4. Distribution of isolated bacteria by service department.

Variables (n)	ICU	Operating room	Maternity	Surgery	Pediatric surgery	Neonatology
P. aeruginosa (15)	100% (15 /15)	0%	0%	0%	0%	0%
S. aureus (62)	32.2% (20 /62)	0%	3.2% (2 /62)	42% (26 /62)	16.1% (10 /62)	6.4% (4 /62)
A. baumannii (3)	100% (3 /3)	0%	0%	0%	0%	0%
E. coli (13)	23% (3 /13)	7.7% (1 /13)	0%	46% (6 /13)	7.7% (1 /13)	13% (2 13)
K. pneumoniae (29)	58.6% (17 /29)	0%	3.4% (1 /29)	27.5% (8 /29)	6.8% (2 /29)	3.4% (1 /29)
Enterococcus (2)	50% (1 /2)	0%	0%	50% (1 /2)	0%	0%

ICU: intensive care unit; *P. aeruginosa*: *Pseudomonas aeruginosa*; *S. aureus*: *Staphylococcus aureus*; *A. baumannii*: *Acinetobacter baumannii*; *E. coli: Escherichia coli*; *K. pneumoniae: Klebsiella pneumoniae.*

Table 5. Distribution of isolated bacteria by sampling sites.

Variables (n)	Trolleys	Sinks	Soap for hand washing	Beds	Taps	Tables
P. aeruginosa (15)	0%	74% (11/15)	6.6% (1/15)	0%	20% (3/15)	0%
S. aureus (62)	42% (26/62)	4.8% (3/62)	11% (7/62)	25.8% (16/62)	1.6% (1/62)	14.5% (9/62)
A. baumannii (3)	0%	66.6% (2/3)	33.3% (1/3)	0%	0%	0%
E. coli (13)	38.4% (5/13)	0%	23% (3/13)	30.7% (4/13)	0%	7.6% (1/13)
K. pneumoniae (29)	24.1% (7/29)	3.4% (1/29)	20.6% (6/29)	34.4% (10/29)	3.4%1 (1/29)	13.7% (4/29)
Enterococcus (2)	0%	0%	50% (1/2)	50% (1/2)	0%	0%

P. aeruginosa: *Pseudomonas aeruginosa*; *S. aureus*: *Staphylococcus aureus*; *A. baumannii*: *Acinetobacter baumannii*; *E. coli: Escherichia coli*; *K. pneumoniae: Klebsiella pneumoniae.*

clustered together, and correlated with *S. aureus*, *K. pneumoniae*, and *E. coli*. Beds and soaps for hand washing clustered together and correlated with *Enterococcus* (Supplementary Figure 3).

Discussion

The hospital environment is largely contaminated by microorganisms of human or specifically environmental origin [9]. Several pathogens responsible for nosocomial infections may survive for months on dry surfaces [9]. Unlike environmental microorganisms, the role of the environment in NI is yet to be well documented [16].

Microbiological sampling from hospital environment represents an essential indicator for hospital hygiene as it allows the determination of the microbial reservoir for nosocomial infections [17].

To the best of our knowledge, this study is the first of its kind carried out in the Mohammed V Hospital located in Al-Hoceima, Morocco, to evaluate the microbiological quality of surfaces in 5 service departments.

The contamination percentage in this study was 34.4% (124/360), which is comparable with the 40% reported by Jaouhar *et al.* [7]. Other reports have described higher frequencies of contamination, including 83% reported by Flouchi *et al.* and 96% reported by Berrada *et al.* [17,18]. This disparity could be explained by the sample size of each study and the differences in surface types and service departments.

The most contaminated service department in this study was the ICU with 50% contaminated isolates (Table 1); and this is comparable to the Tajeddin *et al.* study which reported a rate of 51% [19]. Generally, this department is known for its high contamination due to the diversity in medical procedures, staff, contact with biological fluids, invasive interventions, and diversity and rapidity of medical activities. A randomized cross-over study by Wilson *et al*. reported that high-contact surfaces in ICUs were re-contaminated after a period of 4 hours from the standard cleaning procedures [20].

This study showed that the most contaminated sites were soap for hand washing (27.4%), trolleys (25.8%), and sinks (22.6%) (Table 2). This may be explained by the frequent use of these surfaces by medical staff, as has been well documented [21]. The contamination of soap represents a real problem. The quality of soap dispensers in the hospital should be questioned. It is also highly recommended to avoid the use of soap pieces, which unfortunately continues to be a method of choice.

Gram-positive bacteria were identified in 51.6% of positive samples; which is a lower frequency compared to other studies that described a predominance of Gram-positive pathogens [7,17,18]. This discrepancy may be due to the hospital size, the studied service specificity, the nature of care provided in the departments, the disinfection method, and visitors' access to the departments [22]. Gram-positive bacteria are known to be more resistant to desiccation than Gram-negative bacteria, particularly when surfaces are only cleaned twice a day [23].

S. aureus, *K. pneumoniae*, and *P. aeruginosa* were the most frequently isolated bacteria. These bacteria are known for their nosocomial character and are known to be often involved in severe infections [24].

S. aureus was the most common pathogen in the surgery department (42%), and more specifically on trolleys (Tables 4 and 5). These bacteria are known for their capacity to survive for several days on surfaces [25]. In addition, the presence of *S. aureus* was not surprising due to its opportunistic and ubiquitous nature, that may increase the risk for surgical site infection. *P. aeruginosa* and *A. baumannii* were isolated only in the ICU samples. These bacteria were mostly isolated from wet inert surfaces. *P. aeruginosa* was identified in 74% of sink samples, 20% of taps samples, and 6.6% of hand washing soaps samples. A. *baumannii* was identified in 66.6% of sinks samples and 33.3% of hand washing soaps samples. *A. baumannii* represents a major problem in Morocco and is an emerging cause of nosocomial outbreaks worldwide [26]. It was also recognized by the American Society of Infectious Diseases as one of the most hazardous microorganisms [27]. *E. coli* was frequently isolated from trolleys (38.4% samples) and surgery

department (46% samples). The presence of this pathogen indicates fecal contamination and poor hygiene.

ESBLs were identified in 31% of samples. This rate is similar to that reported by Chaoui *et al.* (32.3%) [4]. In addition, 17.6% of the isolates in this study were MRSA, which is lower than the frequency reported by Chaoui *et al.* (44.7%) [4]. According to Centers for Disease Control and Prevention, MRSA causes more than 70,000 severe infections and 9,000 deaths annually [28]. In this study, MRSA were most frequently isolated from sinks (36.3% samples), trolleys (18.1% samples), and soap (18.1% samples) (Supplementary Table S9). The significant colonization of different surfaces represents a real risk of hand-borne transmission of resistant bacteria, which can cause severe nosocomial infections in the hospital [29].

The surgery and pediatric surgery departments were clustered together based on the distribution of the isolated pathogens, and correlated positively with the pathogens on the beds. The pathogens identified in the ICU were unique compared to those identified in the other service departments. This may be explained by the presence of *A. baumannii* in the ICU. The trolleys and tables clustered together based on the types of pathogens and correlated with *S. aureus*, *E. coli*., and *K. pneumoniae*. The presence of these pathogens on surfaces that are close to patients increases the risk of contamination for patients. The presence of these pathogens in trolleys may increase the risk of operative site infection [30].

Beds and soap for hand washing clustered together and correlated with *Enterococcus*. Generally, these pathogens are found in patient stools and their presence may indicate lack of hygiene during nursing practices and insufficiency in clothing hygiene.

Conclusions

The results show that the quality of hygiene in the hospital was poor and the isolated bacteria were found at different sites and service departments. The bacterial ecology of the hospital depends on the nature of the surfaces (wet and dry surfaces). The pathogens isolated from the hospital surfaces are mainly those that are responsible for nosocomial infections. Therefore, it is important to identify these bacterial species in order to effectively prevent infections. In light of these data, improving hospital hygiene and reviewing disinfection methods through the application of appropriate disinfectant products is recommended. Raising staff awareness through training on hand hygiene, and involvement and commitment of the hospital are also necessary.

Ethic approval

This study was approved by an internal ethics committee (No. 7/SE/2020. Date 10/12/20202).

Data availability

All data used to support the findings of this study are available from the corresponding author upon request.

Authors' contributions

MA, study design, data analysis and interpretation, manuscript preparation—writing and critical revision; SB, study design, manuscript draft; NM, SB, RE, and HE, data analysis and interpretation; MG, statistical analysis and manuscript preparation—critical revision. All authors have reviewed and approved the final version of the manuscript.

Corresponding author

Mostapha Abourrich, PhD.
Street Kadie Ayad, Number 45, Al-Hoceima, Morocco.
Tel: +212 661 246 892
Email: abourich1900@gmail.com

Conflict of interest

No conflict of interest is declared.

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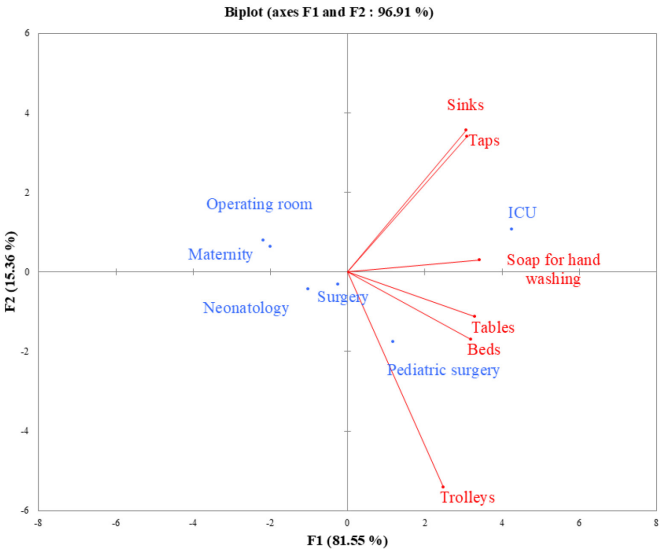
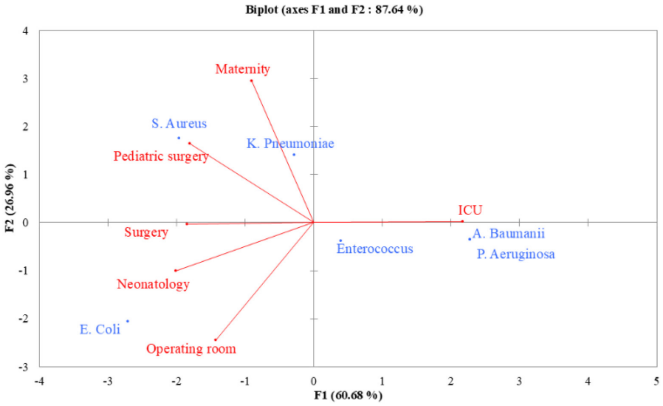
Annex – Supplementary Items

Supplementary Figure 1. Correlation of services by positive sites.



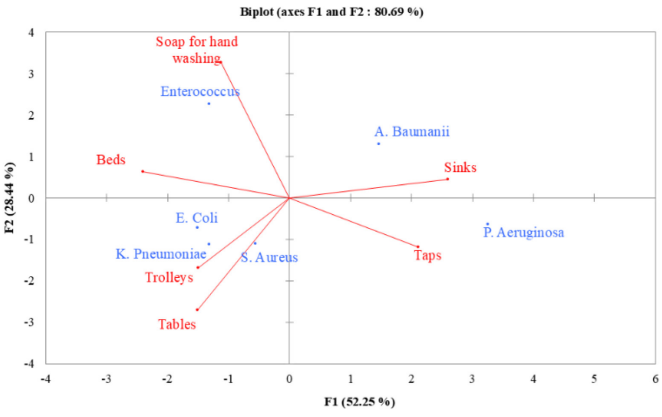
ICU: intensive care unit.

Supplementary Figure 2. Correlation of services by isolated pathogens.



A. baumannii: Acinetobacter baumannii; E. coli: Escherichia coli; ICU: intensive care unit; K. pneumoniae: Klebsiella pneumoniae; P. aeruginosa: Pseudomonas aeruginosa; S. aureus: Staphylococcus aureus.

Supplementary Figure 3. Correlation of sampling sites per isolated germs.



A. baumannii: Acinetobacter baumannii; E. coli: Escherichia coli; K. pneumoniae: Klebsiella pneumoniae; P. aeruginosa: Pseudomonas aeruginosa; S. aureus: Staphylococcus aureus.

Supplementary Table 1. Distribution of collected samples by service departments and sites.

Ward	Bed	Table	Trolleys	Sink	Taps	Soap	Total	
ICU	05	06	10	20	20	20	81	360
Operating room	15	15	15	15	15	15	90	
Maternity	05	05	08	10	05	12	45	
Surgery	04	03	05	05	05	05	27	
Pediatric surgery	05	12	20	10	05	20	72	
Neonatology	05	05	12	06	05	12	45	

ICU: intensive care unit.

Supplementary Table 2. Distribution of *Pseudomonas aeruginosa* by service and sampling type.

Variables % (n)	Trolleys (0)	Sinks (11)	Soap for hand washing (1)	Beds (0)	Taps (3)	Tables (0)
ICU (15)	0%	74% (11 /15)	6.6% (1 /15)	0%	20% (3/15)	0%
Surgery (0)	0%	0%	0%	0%	0%	0%
Pediatric surgery (0)	0%	0%	0%	0%	0%	0%
Neonatology (0)	0%	0%	0%	0%	0%	0%
Maternity (0)	0%	0%	0%	0%	0%	0%
Operating room (0)	0%	0%	0%	0%	0%	0%

ICU: intensive care unit.

Supplementary Table 3. Distribution of *Acinetobacter baumannii* by service and sampling type.

Variables % (n)	Trolleys (0)	Sinks (2)	Soap for hand washing (0)	Beds (0)	Taps (1)	Tables (0)
ICU (3)	0%	75% (2/3)	0%	0%	33.3% (1/3)	0%
Surgery (0)	0%	0%	0%	0%	0%	0%
Pediatric surgery (0)	0%	0%	0%	0%	0%	0%
Neonatology (0)	0%	0%	0%	0%	0%	0%
Maternity (0)	0%	0%	0%	0%	0%	0%
Operating room (0)	0%	0%	0%	0%	0%	0%

Supplementary Table 4. Distribution of *Staphylococcus aureus* by service department and sampling type.

Variables % (n)	Trolleys (26)	Sinks (3)	Soap for hand washing (7)	Beds (16)	Taps (1)	Tables (9)
ICU (20)	45% (9/20)	0%	15% (3/20)	15% (3/20)	0%	25% (5/20)
Surgery (26)	53.3% (14/26)	3.8% (1/26)	7.7% (2/26)	19.2% (5/26)	3.8% (1/26)	11.5% (3/26)
Pediatric surgery (10)	20% (02/10)	10% (1/10)	10% (1/10)	50% (5/10)	0%	10% (1/10)
Neonatology (4)	25% (01 /4)	0%	25% (01/4)	50% (02/4)	0%	0%
Maternity (2)	0%	50% (1/2)	0%	50% (1/2)	0%	0%
Operating room (0)	0%	0%	0%	0%	0%	0%

ICU: intensive care unit.

Supplementary Table 5. Distribution of *Escherichia coli* by service department and sampling type.

Variables % (n)	Trolleys (5)	Sinks (0)	Soap for hand washing (3)	Beds (4)	Taps (0)	Tables (1)
ICU (3)	33.3% (1/3)	0%	16.6% (1/3)	16.6% (1 /3)	0%	0%
Surgery (6)	60% (3/5)	0%	20% (1/ 5)	20% (1/5)	0%	20% (1/5)
Pediatric surgery (1)	0%	0%	0%	100% (1/1)	0%	0%
Neonatology (2)	50% (1/2)	0%	0%	50% (1/2)	0%	0%
Maternity (1)	0%	0%	100% (1/1)	0%	0%	0%
Operating room (0)	0%	0%	0%	0%	0%	0%

ICU: intensive care unit.

Supplementary Table 6. Distribution of *Klebsiella pneumoniae* by service department and sampling type.

Variables % (n)	Trolleys (7)	Sinks (1)	Soap for hand washing (6)	Beds (10)	Taps (1)	Tables (4)
ICU (17)	29.4% (5/17)	0%	17.6% (3/17)	41.1% (7/17)	0%	11.7% (2/17)
Surgery (8)	12.5% (01/8)	12.5% (01/8)	14.2% (3/8)	12.5% (1/8)	12.5% (1/8)	12.5% (1/8)
Pediatric surgery (2)	50% (01/2)	0%	0%	50% (1/2)	0%	0%
Neonatology (1)	0%	0%	0%	100% (1/1)	0%	0%
Maternity (1)	0%	0%	0%	0%	0%	100% (1/1)
Operating room (0)	0%	0%	0%	0%	0%	0%

ICU: intensive care unit.

Supplementary Table 7. Distribution of *Enterococcus* by service department and sampling type.

Variables % (n)	Trolleys	Sinks	Soap for hand washing (1)	Beds 1	Taps	Tables
ICU (1)	0%	0%	100% (1/1)	0%	0%	0%
Surgery (1)	0%	0%	0%	100% (1/1)	0%	0%
Pediatric surgery (0)	0%	0%	0%	0%	0%	0%
Neonatology (0)	0%	0%	0%	0%	0%	0%
Maternity (0)	0%	0%	0%	0%	0%	0%
Operating room (0)	0%	0%	0%	0%	0%	0%

ICU: intensive care unit.

Supplementary Table 8. Distribution of resistant bacteria by service department.

	ICU	Operating room	Maternity	Surgery	Pediatric surgery	Neonatology
ESBL (13)	30.7% (4/13)	0%	7.7% (1/13)	38.4% 5/13)	15.3% (2/13)	7.7.3% (1/13)
MRSA (11)	27.2% (3/11)	0%	0%	36.3% (4/11)	18.1% (2/11)	18.1% (2/11)

ICU: intensive care unit; ESBL: e*xtended-spectrum beta-lactamase*; MRSA: methicillin-resistant *Staphylococcus* aureus.

Supplementary Table 9. Distribution of resistant bacteria by sampling sites.

Variables % (n)	Trolleys	Sinks	Soap for hand washing	Beds	Taps	Tables
ESBL (13)	23% (3/13)	38.4% (5/13)	7.7% 1/13	7.7% 1/13	15.3% (2/13)	7.7% 1/13
MRSA (11)	18.1% (2/11)	36.3% (4/11)	18.1% (2/11)	1% (1/11)	1% (1/11)	1% (1/11)

ICU: intensive care unit; ESBL: Extended-spectrum beta-lactamase; MRSA: methicillin-resistant *Staphylococcus aureus.*

Supplementary Table 10. Distribution of isolated ESBLs by service department and sampling type.

Variables % (n)	Trolleys (3)	Sinks (5)	Soap for hand washing (1)	Beds (1)	Taps (2)	Tables (1)
ICU (4)	25% (1/4)	50% (2/4)	0%	0%	25% (1/4)	0%
Surgery (5)	40% (2/5)	20% (1/5)	20% (1/5)	20% (1/5)	0%	0%
Pediatric surgery (2)	0%	50% (1/2)	0%	0%	50% (1/2)	0%
Neonatology (1)	0%	0%	0%	0%	0%	100% (1/1)
Maternity (1)	0%	100% (1/1)	0%	0%	0%	0%
Operating room (0)	0%	0%	0%	0%	0%	0%

ICU: intensive care unit; ESBL: Extended-spectrum beta-lactamase.

Supplementary Table 11. Distribution of isolated MRSA by service and sampling type.

Variables % (n)	Trolleys (2)	Sinks (4)	Soap for hand washing (2)	Beds (1)	Taps (1)	Tables (1)
ICU (3)	25% (1/2)	50% (1/2)	33.3% (1/3)	0%	0%	0%
Surgery (4)	33.3% (1/3)	66.6% (2/3)	33.3% (1/3)	0%	0%	0%
Pediatric surgery (2)	0%	0%	0%	50% (1/2)	0%	50% (1/2)
Neonatology (2)	0%	50% (1 /2)	0%	0%	0% (1/2)	0%
Maternity (0)	0%	0%	0%	0%	0%	0%
Operating room (0)	0%	0%	0%	0%	0%	0%

ICU: intensive care unit; MRSA: methicillin-resistant *Staphylococcus aureus.*