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Strengthening Environmental Hygiene for Healthcare-associated Infections Prevention in Maternity Ward: Outstanding Findings from a Multisite Survey in the Ndé Division, West Cameroon

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: In health facilities, mothers and their children are amongst the most vulnerable groups likely to contract healthcare-associated infections.

Aim: The present investigation aimed at characterizing bacterial groups (profile, load, antibiotic susceptibility) in maternity premises of Bangangté District Hospital (BDH) and "Université des Montagnes" Teaching Hospital (UdMTH), Ndé Division – West Cameroon.

Methods: From September 2nd through November 2nd, 2019, the work was focused on surfaces and airborne bacteria. Specimen collection was conducted by wet surface swabbing and passive adhesion of airborne bacteria, respectively. Isolation, enumeration, identification and susceptibility tests were carried out according to standard bacteriological protocols.

Results: Out of 126 specimens collected and screened, 98.4% resulted in positive cultures. A total of 168 isolates were then recovered, consisted of *Staphylococcus* spp. (68% and 51%), Gram-positive rods (30% and 35%) and Gram-negative rods (2% and 14%), in UdMTH and BDH, respectively. Bacterial profile recorded were almost similar in all specimens subjected. Bacterial loads varied greatly (as low as $<$ 10 CFU/cm² on surfaces or $<$ 283 CFU/60 mm diameter Petri dish for airborne bacteria and as high as > 30 CFU/cm² on surfaces or > 848 CFU/60 mm diameter Petri dish for airborne bacteria). Bacterial loads appeared to be likely in connection with local activity density. Susceptibility tests revealed high resistance rates while Imipenem was most potent.

Conclusion: Overall findings are reliable clue that could guide advocacy for infections prevention through mitigation of contamination risks in health facilities.

Keywords: Ambient air; bacteria; health environment; healthcare associated infections; maternity; surface.

1. INTRODUCTION

Observed at the global scale, healthcare facilities are conducive ecosystems that promote selection and spread of etiologies of healthcare associated infections (HAIs) [1]. In this environment, HAIs are caused by infectious agents that easily disseminate through (but not limited to) hands, equipment, medical devices and air [2,3]. Also referred to as nosocomial infections, healthcare associated infections are disorders caused by microorganisms contracted during a stay in a healthcare facility [4]. They have long been serious causes of concern for hospitalized patients in connection with their frequency, their severity and related economic burdens. Moreover, and over time, patients with HAIs undergo progressive weakening of their immune system which eventually increase mortality and morbidity rates in susceptible hosts [5]. The risk of developing life-threatening hospital bacterial infections increases when the agents are resistant to available and affordable drugs [3,6]. Globally, the resistance rates amongst potential etiologies of HAIs are high and include those recorded with methicillin-resistant *Staphylococcus*, multidrug resistance Gram-negative rods (*Klebsiella* spp., *Enterobacter* spp., *Acinetobacter* spp., *Pseudomonas* spp.), and vancomycin-resistant *Enterococcus* [7].

Among the barriers set up against HAIs in healthcare facilities nowadays, the quality of patient care is a priority. This is otherwise, firmly associate with the management of healthcare environments in order to mitigate the selection and spread of potential infectious agents. These options are provided by the general policy in force in each site and serves as driver to the concept of "hospital hygiene", fundamental in controlling microbial populations in the patient's environment [4]. Another one relies on the surveillance of antibiotic resistance trends in the hospital environment. Although the role of antibiotics is proved to be very valuable in the fight against bacterial diseases in living systems, their use in healthcare environments, animal husbandry and crop production is regarded as engine for selection of resistance traits. Their use in prophylaxis and growth supplementation, for instance, are common practices in resource-limited communities since members can hardly afford biological evidences prior to drug administration. In turn, this practice further threatens the validity of available therapeutic arsenal [8] in a vicious cycle.

Mitigating HAIs is primordial in high-risk environments like maternity wards where potential hosts are typically vulnerable [9]. Mastering the environmental microbiological flora to which mothers and children are exposed during hospital stay appears paramount requirement for safer healthcare services. Within the framework aiming at monitoring the bacterial flora in the global strategy targeting mitigation of resistant HAIs, the present survey was initiated. It specially aimed at characterizing the bacterial groups present in maternity unit environment and disclosing the antibiotic susceptibility/resistance profile of those that are potential etiologies of HAIs. This work is part of a broader program investigating tools likely to contribute to the strengthening of quality care at "Université des Montagnes" teaching hospital and Bangangté District Hospital (Ndé division, West-Cameroon) in which reservoirs of multi-resistant bacteria have consistently been reported [10-12].

2. MATERIALS AND METHODS

2.1 Study Design

This cross-sectional descriptive study was conducted from September 2nd through November 2nd, 2019 in maternity wards of "Université des Montagnes" teaching hospital (UdMTH) and Bangangté District Hospital (BDH), two health facilities in Ndé division, West-Cameroon. Sampling was initiated when all administrative and ethical requirements were met. Namely, they were the ethical clearance N°2019/031/UdM/PR/CIE provided by the institutional ethical board, the research authorization N°2019/059/AED/UDM/CUM obtained from the UdMTH head and the signed written agreement from the BDH director. Subsequent to data collection and sampling, bacteriological screening was performed at the Microbiology Laboratory of UdMTH.

2.2 Sampling and Bacteria Analysis

The specimens subjected were collected from childbirth and hospital rooms. Targeted specimens and collection sites included airborne bacteria in the work-place and surfaces of some tools (flat surfaces of childbirth tables, instrument tables and the scale). Prior to each sampling, various sets of related pieces of information were collected for tracing.

Specimen collection was performed by wet swabbing on flat surfaces and by passive direct contact (sedimentation) for airborne bacteria according to Fotsing Kwetche *et al*. [12]. Sampling was conducted over three days; three times per day. On surfaces, the procedure was repeated at 9 a.m., 11 a.m. and 1 p.m. For airborne bacteria, open Petri dishes with culture media were deposited at 9 a.m. and the three sampling times corresponded to time differences of 45 min (air sample 1), 1 hour (air sample 2) and 1 h 30 min (air sample 3) from the opening to the closing of dishes.

The analytic protocol followed according to Fotsing Kwetche *et al*. [12] with slight adjustments. After enumeration, bacterial loads were recorded and characterized. They were thus classified as low for loads below 10 CFU/cm² on surfaces or 283 CFU/60 mm diameter Petri dish for airborne bacteria, high for loads above 30 CFU/cm² on surfaces or 848 CFU/60 mm diameter Petri dish for airborne bacteria, and moderate for loads found between these two extremes for each type of specimen. In this work, Gram-positive rods (GPR) were not enumerable (slick growth). During the identification, tests for nitrate reductase, indole and TDA were added for Gram-negative rods (GNR). For each type of isolates, three colonies were randomly selected, re-streaked on nutrient agar and used individually in susceptibility tests. For each health facility, 30% of isolates were later reselected for susceptibility tests. The susceptibility tests were performed according to recommendations of "Comité de l'Antibiogramme de la Société Française de Microbiologie, CA-SFM, EUCAST, V2.0 May 2019". A total of 11 antibacterial agents selected and used for this purpose. Namely, they were Amoxicillin (25 µg), Amoxicillin/Clavulanic Acid (20/10 µg), Cefoxitin (30 µg), Ceftriaxone (30 µg), Cefuroxime (30 µg), Gentamicin (15 µg), Imipenem (10 µg), Levofloxacin (05 µg), Nalidixic Acid (30 µg), Penicillin G (10U), and Tetracycline (30 µg).

2.3 Data Processing and Expected Outcomes

Expected pieces of information included bacterial isolation rates and loads; antibiotic susceptible/resistant isolates profile. These variables were recorded and analyzed with statistical tools provided by Microsoft Excel 2013 software.

3. RESULTS

3.1 Observational Findings

In target health facilities, maternity care activities were diversified. The decontamination protocol in force was conducted in two major steps at UdMTH i.e. cleaning with tap water and detergent, and disinfection with chlorinated water. In BDH, three steps were observed and included in order cleaning with tap water and detergent, disinfection with chlorinated water and disinfection with 70% alcohol. These protocols were not consistently followed due to unavailability of disinfectant and decontamination solutions in both settings.

3.2 Bacterial Presence

Overall, 126 specimens were collected (81 at UdMTH and 45 at BDH). From these, 168 bacterial isolates were recovered (65 from BDH and 103 from UdMTH). Further details on the distribution of specimens and positive cultures are shown in Table 1. Overall, 98.4% of cultures were positive. Identification resulted in diversified bacterial polymorphism in all settings.

More detailed related pieces of information on the distribution of recovered isolates per sites are provided in Fig. 1. and Table 2.

Bacterial diversity was higher at BDH. In addition, most bacterial groups were coagulase negative staphylococci, they were followed by Gram-positive rods. Globally, similar profile was observed from one site to the other. Also, in-site variation trends were similar from one location to the other. Otherwise, the ambient air and the work surfaces of each room were colonized by slightly similar bacterial groups. From one hospital to the other, this similarity was observed between specimen collection sites. The highest bacterial diversity were recorded on the instrument table 1 (IT 1) at the UdMTH hospital room and the instrument table (IT) at the BDH childbirth room. CNS numbers predominated isolation rates, except on scales where GPR were more recovered.

Although the composition according to the bacterial profile was approximately similar, the composition in connection with bacterial loads was very diverse. Tables 3 and 4 provide more details on these loads.

Table 1. Rates of positive cultures

Specimens and cultures information	"Université des Montagnes" Teaching Hospital		Bangangté District Hospital		Total
	Childbirth room	Hospital room	Childbirth room	Hospital room	
Specimen number	54	27	42	3	126
Positive cultures (%)	98.1	96.3	100	100	-
Number of bacterial isolates	69	34	61	4	168

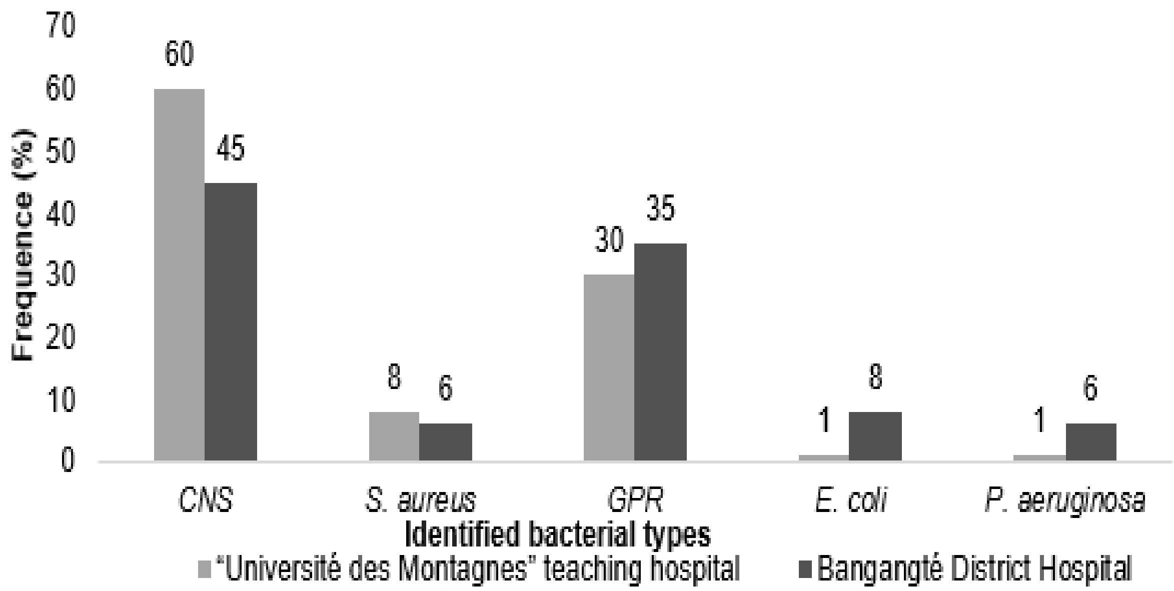

Fig. 1. Distribution of bacteria isolates per health facility

CNS: Coagulase negative Staphylococcus; GPR: Gram-positive rods

Table 2. Bacterial group per sampling site

Health facilities	Collection sites	Specimens	Bacterial type				
			GPR	*E. coli*	*P. aeruginosa*	*S. aureus*	CNS
UdMTH	CR	Air	04	00	00	00	07
		S	09	00	00	00	06
		CT 1	01	00	00	03	05
		CT 2	05	00	00	01	06
		CT 3	04	00	00	02	06
		IT	02	00	00	00	08
	HR	Air	02	00	00	00	09
		IT 1	01	01	01	01	08
		IT 2	03	00	00	00	08
BDH	CR	Air	04	00	00	00	08
		S	07	02	00	01	05
		CT 1	03	00	03	01	04
		CT 2	04	02	00	01	05
		IT	04	01	01	01	04
	HR	IT	01	00	00	00	03

UdMTH: "Université des Montagnes" teaching hospital; BDH: Bangangté District Hospital; CR: Childbirth room; HR: Hospital room; S: Scale; CT: Childbirth table; IT: Instrument table; CNS: Coagulase negative Staphylococcus; GPR: Gram-positive rods

Table 3. Load of enumerable airborne bacteria

Sampling information		UdMTH		BDH
		CR	HR	CR
		CFU of CNS/60 mm diameter Petri dish		
Day 1	Air specimen 1	1000	53	16
	Air specimen 2	1000	54	1000
	Air specimen 3	1000	56	1000
Day 2	Air specimen 1	-	4	3
	Air specimen 2	-	25	1000
	Air specimen 3	1000	40	-
Day 3	Air specimen 1	24	30	1000
	Air specimen 2	02	37	1000
	Air specimen 3	1000	33	04

UdMTH: "Université des Montagnes" teaching hospital; BDH: Bangangté District Hospital; CR: Childbirth room; HR: Hospital room; CNS: Coagulase negative Staphylococcus; CFU: colony-forming unit

The overall bacterial loads varied significantly (50%) or remain similar (50%) between the different collections of airborne bacteria from each room at UdMTH. The bacterial density of CNS (Table 3) was, in more than half of cases (5 out of 9), very high in childbirth rooms. In UdMTH, these loads were 18 to 33 times higher than findings recorded in hospital wards.

Overall, work surfaces (Table 4) were colonized by a fairly high bacterial load (31 - 100 CFU/cm^2), at least once. In addition, at UdMTH, except the childbirth table 2 (CT 2), work surfaces were often colonized by very high bacterial load (> 300 CFU/cm^2). At BDH, bacterial loads on surfaces were very high in the majority of cases. Per sampling day, bacterial loads often remained relatively constant on surfaces (5.1% of cases).

3.3 Bacteria Susceptibility Profile

Susceptibility tests revealed high rates of drug resistance and multidrug-resistant isolates; most of which were potential etiologies of healthcare associated infections.

Table 5 provides further detailed pieces of findings on the isolate's susceptibility/resistance profile. Overall, 50 isolates were subjected.

It appears that some bacterial isolates were resistant to several antibacterial drugs families. Overall, the lowest resistance rates were recorded with Imipenem while the majority of the antibiotics used have a better effectiveness at UdMTH.

Table 4. Bacterial loads (CFU/cm²) of enumerable isolates on surfaces per site

Hospitals	Sites	Work surfaces	Enumerated bacterial types	Collecting period								
				Day 1			Day 2			Day 3		
				9 a.m.	11 a.m.	1 p.m.	9 a.m.	11 a.m.	1 p.m.	9 a.m.	11 a.m.	1 p.m.
UdMTH	CR	S	CNS	-	-	-	400	400	400	400	400	400
		CT 1	CNS	-	-	-	35	5	42	23	400	-
			S. aureus	8	400	40	-	-	-	-	-	-
		CT 2	CNS	-	-	-	17	5	5	2	2	1
			S. aureus	-	68	-	-	-	-	-	-	-
		CT 3	CNS	-	-	-	51	11	108	400	400	14
			S. aureus	38	120	-	-	-	-	-	-	-
		IT	CNS	-	360	11	99	86	16	4	400	400
	HR	IT 1	CNS	-	42	12	99	30	16	20	400	400
			S. aureus	58	-	-	-	-	-	-	-	-
			P. aeruginosa	-	-	-	-	-	-	-	400	-
			E. coli	-	-	-	-	-	-	-	-	10
		IT 2	CNS	400	400	400	400	7	400	-	400	400
BDH	CR	S	CNS	-	-	-	170	-	400	400	2	10
			S. aureus	-	-	-	-	400	-	-	-	-
			E. coli	-	-	-	-	-	-	320	400	-
		CT 1	CNS	-	-	400	-	-	-	400	400	400
			S. aureus	-	-	-	256	-	-	-	-	-
			P. aeruginosa	400	400	400	-	-	-	-	-	-
		CT 2	CNS	-	400	-	400	-	400	2	400	-
			S. aureus	-	-	-	-	400	-	-	-	-
			E. coli	-	-	400	-	-	-	-	-	400
		IT	CNS	No sampling			2	-	400	2	400	-
			S. aureus				-	43	-	-	-	-
			P. aeruginosa				-	-	-	-	-	6
			E. coli				-	-	-	-	18	-
	HR	IT	CNS	400	400	3	No sampling					

UdMTH: "Université des Montagnes" teaching hospital; BDH: Bangangté District Hospital; CR: Childbirth room; HR: Hospital room; S: Scale; CT: Childbirth table; IT: Instrument table; CNS: Coagulase negative Staphylococcus; CFU: colony-forming unit

Table 5. Bacterial clinical categories (%) at UdMTH and BDH

Antibiotics	UdMTH (n=31)			BDH (n=19)		
	%S	%I	%R	%S	%I	%R
Amoxicillin (25 µg)	13	00	87	13	00	87
Amox/Clav (20/10 µg)	27	00	73	13	00	87
Cefoxitin (30 µg)	13	20	67	00	13	87
Ceftriaxone (30 µg)	13	07	80	07	26	67
Cefuroxime (30 µg)	10	00	90	00	00	100
Gentamicin (15 µg)	23	70	07	07	86	07
Imipenem (10 µg)	77	13	10	58	42	00
Levofloxacin (05 µg)	19	68	13	21	58	21
Nalidixic Acid (30 µg)	00	00	100	00	00	100
Penicillin G (10 U)	28	00	72	40	00	60
Tetracycline (30 µg)	00	26	74	00	37	63

UdMTH: “Université des Montagnes” teaching hospital; BDH: Bangangté District Hospital; R: Resistant; S: Susceptible; I: Intermediate; Amox/Clav: Amoxicillin/Clavulanic Acid

4. DISCUSSION

The present investigation aimed at characterizing the bacterial groups present in maternity ward environment of two health facilities in Ndé Division, appreciating their variation with time and determining the antibiotic susceptibility/resistance profile of isolates that are potential agents of healthcare-associated infections. In each health facility, Gram-positive cocci predominated, followed by Gram-positive rods. Similar tends were reported by previous research in same facilities a few years ago [10-12]. Consistent with previous authors, colonization by these bacterial groups could actually be anticipated, based on their non-stringent feature which allows their easy growth in diverse environmental constraints. Nothing was planned to appreciate the hygiene follow-up but, although it is known to have improved meanwhile, developing monitoring policies to serve as a routine process emerge as a health priority. This is feasible in this area which is endowed with multiple assets like human resources which are listed amongst the best capacitated in West region of Cameroon.

This predominance could be justified by intrinsic characteristics of these bacteria. These include (but not limited to) the chemical composition of the cell envelope, their affinity with molecular oxygen, non-stringency in connection with nutritional demands and other environmental stresses like dry and hot environments. Moreover, some GPR from the genus *Bacillus*, can develop spores that further promote resistance to environmental stresses imposed by detergents, for instance, that bare commonly substances used in routine cleaning [10-12]. Strains from this group are common hosts of surfaces in healthcare settings. Based on the low and intermediate virulence of most species, bacteria belonging to the genus *Bacillus* are often regarded as deserving little or no importance in infectious diseases [13]. With advances in medicine that associate with increased life expectancy and the number of vulnerable hosts in elderly, their potential role as etiologies of resistant opportunistic infections in healthcare environment became obvious [14]. Previous authors suggested that Gram-positive bacteria like *Staphylococcus* spp., could effectively serve to monitor the density of bacterial population in work environments [12].

Also, and consistent with above development, the higher rates of Gram-negative rods recorded at BDH could be, at least partially, justified by the fact that BDH work surfaces more frequently humidified with water during specimen collection. This aligns with the hypothesis on wet environments which favor survival and growth of Gram-negative rods [2,15] including *P. aeruginosa* in the hospital environment [15], as well as the sample collection protocol effectiveness which optimizes removal of bacteria from target surfaces [16-19]. In quality control, detection of Gram-negative rods (coliforms, more specifically) typically indicates recent adulteration of the collection site. Otherwise, their presence would reflect weaknesses in preserving proper environment for safer healthcare; a key priority to be addressed. During childbirth, feces, and the residues of feces can contaminate work surfaces and equipment, as well as hands of care providers; underlining the necessity for sustainable running water availability. Their presence, like as that of bacteria types such as *S. aureus* and *P. aeruginosa*, is a risk for healthcare-associated infections in at-risk individuals.

The similarity primarily observed in bacteria profile indicates a bacteria population's homogeneity. The minor differences recorded between profiles of these bacterial groups could be explained by the intrinsic variability associated with each activity, the healthcare workers aptitude, the type of healthcare services offered, and constrains due to resource availability. For example, the scale is used to weigh the newborn after birth. The predominance of GPR on this tool could be the consequence of its contamination by bacteria present on the child immediately after birth. Many bacteria present on child just after birth are those of the mother's microbial vaginal flora, which mainly include GPR [20,21]. Moreover, loads of bacteria on work surfaces in childbirth rooms were high, in line with developments from previous authors [22]. Air adulteration may explain the contamination of some unused surfaces such as the childbirth table 2 at UdMTH. Smith *et al*. [23]; Fotsing Kwetche *et al*. [12] reporting association between air and surface bacterial loads asserted that passive air sampling effectively provides quantitative data likely to assess surface contamination. However, it appears primordial to include large numbers of sampling points when airborne bacteria loads are investigated through. On surfaces, wide variations in bacterial loads (from low to very-high) and population heterogeneity were observed with time during the present survey. It is recognized that humans' presence and activities have great impacts on the microbial population on ward's surfaces (> 30 CFU/cm²). The high load increases the risk of HAIs and represent indirect evidence of weaknesses in healthcare hygiene policies in force. Such bacterial loads highlight the importance of decontaminating the care environment which is one of key objectives of hospital hygiene. This impact is also recalled and defended by several authors [1,24]. Various data suggest basic cheaper and available tools that could be used in strategizing policies aiming effective decontamination in instances of resource limitation [25].

In the context of the present investigation, the high resistance rates recorded is a predictor of therapeutic failure in case identified organisms will become involved in infections. The resistance rates recorded could at first glance be attributed to the use of antimicrobial drug as it is known to take place in healthcare settings. Consistently however, research findings indicate that community-selected resistance shouldn't be overlooked [26,27]. In fact, the potential of healthcare facilities to screen microbial susceptibility/resistance profiles prior to drug administration is few in Ndé division. Otherwise, in most cases drug administration empirically oriented, favored by the low purchasing power of the general population on one hand and the human resource at both clinical and biological levels. This gape should be address for effective and sustainable antimicrobial resistance stewardship that is at its early steps in Cameroon.

A glance on this susceptibility trends as introduced above reveals low rates. The low susceptibility has been reported by authors in same facilities a few years ago [10-12], also associated with likely cross- or co-selection. This may be in connection with the routine use of antibiotics and sometimes inappropriate use in the hospital setting as developed above [28]. Moreover, it could also result from the dissemination of resistance genes carried by mobile genetic elements from other resistance-selection engines as animal husbandry and agriculture. Animal husbandry and agriculture in Ndé division should therefore, be regarded as drivers on which AMR should focus, beyond healthcare settings. These consistently high resistance rates are additional paramount indications that advocate holistic and sustainable stewardship policies.

Still from these findings, it can be anticipated that targeting a few sites in the hospital would provide an overall idea of the microbial flora of this environment, although specific pieces of information will be required for a better infection prevention initiative from one place to the other [14,29]. Current findings globally point out the necessity for infection control policies revision that will encompass the flexible local hospital environments which host several variants of susceptible hosts (newborns and elderly). They ultimately provide a few reliable tools that will be useful in the AMR stewardship in Cameroon. Further pieces of information and reliable indicators likely to attest bacteria spread from one site to the other will be key targets in future investigations.

5. CONCLUSION

Strengthening environmental hygiene is essential to guarantee the safer healthcare services and prevent healthcare-associated infections. The knowledge of the microbial flora in the healthcare environment provides the data needed to achieve this. In maternity units of Bangangté District Hospital and "Université des Montagnes" teaching hospital, bacterial groups, mainly *Staphylococcus* spp., on work surfaces and in ambient air of work premises were globally found with high loads during this investigation. These findings were likely in connection with local activity density. The susceptibility/resistance rates also fluctuated in recovered isolates. Overall, these results highlighted the need for strengthening work-environment hygiene for safer mothers-and-child.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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