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Effectiveness of a Low-Cost Cleaning and Disinfection Protocol on Hospital Surfaces: A Before–After Microbiological Assessment in a Resource-Limited Teaching Hospital

Ahmed Ben Ali[1], Youssef Trabelsi[1], Sami Bouaziz[1]*

[1]Department of Biomedical Sciences, Faculty of Medicine, University of Tunis El Manar, Tunis, Tunisia.

***E-mail** ✉ sami.bouaziz.bio@yahoo.com

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ABSTRACT

A considerable portion of infections arising in medical settings is linked to the hygienic status of the working environment, often tied to inadequate sanitation. To determine how well a combined procedure (cleaning + disinfection) worked at the "Université des Montagnes" Teaching Hospital, this study measured how surface bacterial loads changed after decontamination. The study also examined how isolated bacteria reacted to selected disinfectants. Adjusted protocols for detecting, counting, and testing susceptibility were used alongside standard identification methods. Surface samples were taken by moist swabs before cleaning, after cleaning but prior to disinfection, and again post-disinfection. Findings showed that Staphylococcus dominated samples (75.5%). Elevated bacterial counts found prior to decontamination became non-detectable once cleaned with "Pax lemon." Most strains (98%) were sensitive to the disinfectants assessed, namely Surfanios® 0.25% and sodium hypochlorite 0.12%.Collectively, these outcomes point to the procedure's effectiveness and support the use of Surfanios® (0.25%) or sodium hypochlorite (0.12%) for maintaining surface hygiene. The combination of "Pax lemon" detergent for cleaning, followed by sodium hypochlorite disinfection, appears adequate for the surface types examined.

Keywords: Bacteria, Decontamination, Hospital, Surfaces

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Introduction

Medical environments can harbor extensive microbial populations capable of contaminating, colonizing, and causing disease in people receiving or providing care [1–4]. Such organisms may include opportunistic or professional pathogens with notable antimicrobial resistance and may spread unpredictably between humans and their surroundings [4–7]. Their detection signals potential healthcare-associated infection (HAI) risks and possible transmission of hospital-linked microbes beyond the facility [5–8]. HAIs result from or are associated with microorganisms acquired within healthcare settings. According to commonly cited literature, organisms frequently encountered include vancomycin-resistant Enterococcus, Clostridium difficile, multidrug-resistant Gram-negative species such as Pseudomonas spp. and Acinetobacter spp., methicillin-resistant Staphylococcus aureus, and norovirus [3–7].

The presence of microbes and the likelihood of infection depend—among other elements—on how spaces are used, the environmental microbiota, transmission dynamics (often not fully understood), microbial entry points, and the susceptibility of hosts; vulnerability typically rises with length of stay, age, and underlying health conditions. Consequently, risks differ throughout a facility [1, 5, 7]. For this reason, factors such as patient-care quality, maintenance of premises, equipment hygiene, and hand sanitation are crucial components of HAI prevention. To manage these issues globally, facilities have adopted, strengthened, and normalized "hospital hygiene," aimed at reducing and managing infection risk [7, 8]. Before the 1990s, this was viewed mainly as a cosmetic concern and a target for budget cuts due to limited empirical support for its impact on HAIs [7]. Within

this framework, a key measure is the decontamination of areas and materials through cleaning alone or combined with disinfection or sterilization [9].

Currently, it is well recognized that infectious agents—such as those noted above—transfer readily from surfaces to healthcare workers' hands and to reusable tools. Once contaminated, these items can convey organisms to patients or between patients. Moreover, infection likelihood increases when a new patient is assigned to a room previously occupied by someone colonized or infected [3, 4]. Likewise, consistent adherence to hygiene protocols significantly limits environmental pathogen presence and decreases infection risk [4]. Therefore, healthcare facilities must ensure that cleaning personnel apply decontamination procedures correctly.

Throughout the world, discussions continue regarding how often decontamination should occur, what methods and tools should be used, and how procedures ought to be monitored or standardized [10, 11]. Because of wide differences in environmental flora, building materials, and architectural layouts, it remains essential to promote context-specific protocols [3]. Scientifically validated assessments of hygiene procedure effectiveness are required to support the selection of optimal and economical approaches within healthcare environments [4, 7, 12].

At the "Université des Montagnes" Teaching Hospital (UdMTH), multiple studies have explored the local microbial landscape. These investigations repeatedly highlighted concerns about infectious hazards, noting frequent elevated bacterial loads and patterns suggesting spread across zones, underscoring the importance of establishing local benchmarks [8, 13, 14]. The primary goal of the present study was to evaluate how well the decontamination practices in place at UdMTH worked. Focusing on the biomedical analysis laboratory, this project aimed to characterize bacterial communities found on work surfaces before and after decontamination, using a prior analytical framework [15]. A second objective was to determine the isolate tolerance or sensitivity to commonly used disinfectants. The resulting dataset could reinforce microbiological safety locally, provide insights for other facilities in Cameroon, and contribute to refining contextual sanitation strategies.

Materials and Methods

Study design

A descriptive cross-sectional survey was conducted at UdMTH between May 4th and June 16th, 2020, under research permit N°. 2020/052/AED/UDM/CUM granted by the hospital leadership and ethics approval N°. 2020/147/UdM/PR/CIE from the "Université des Montagnes" ethics board. The study area consisted of work surfaces within the UdMTH biomedical analysis laboratory, where sampling, handling, and testing were performed.

Decontamination protocol

The protocol consisted of two phases: cleaning followed by disinfection. Core materials included absorbent paper (standard wide examination sheet; 50 × 34 cm), concentrated Surfanios® disinfectant (ANIOS®), the detergent "Pax lemon," and sodium hypochlorite (2.4%) "la croix" from COLGATE-PALMOLIVE® Cameroon. These were chosen because they were routinely used at UdMTH, and many Cameroonian facilities rely primarily on chlorinated solutions.

During application, the detergent was diluted 1/20 in tap water for the cleaning step, while disinfectants were diluted in tap water to obtain Surfanios® 0.25% or sodium hypochlorite 0.12%. Examination sheets were folded to produce sections one-quarter the original size. This protocol targeted a 900 cm² area (30 × 30 cm).

In brief, surfaces were scrubbed using folded examination paper moistened with the cleaning solution, wiped with a dry folded piece, rinsed with a tap-water-soaked folded sheet, and dried again with sterile folded paper. Next, disinfectant was applied with a sterile folded sheet saturated with the chosen product. The complete procedure appears in **Table 1.**

Table 1. Surface decontamination protocol.

Steps	Description
1	Saturate one side of the folded examination sheet with **20 mL** of the cleaning agent.
2	Using the dampened side, polish the target surface by moving in an outward circular motion (from the center toward the edges) for **10 s**; flip the sheet and repeat the same motion and duration using the dry opposite side.

3	Carry out the procedure described above **one more time**.
4	Dry the treated surface with a different folded examination sheet.
5	Moisten one side of a fresh folded examination sheet with **20 mL** of tap water.
6	Reapply the technique outlined in step **2**.
7	Use a sterile folded sheet to wipe the surface afterward.
8	Wet one side of a new sterile folded examination sheet with **15 mL** of the disinfectant.
9	Rub the previously cleaned area using the moistened side, following the same circular pattern and time used earlier.
10	Leave the surface to air-dry and restart activities after **15 min**.

Work surface selection

Four planar surfaces were chosen, all located in the UdMTH Biomedical Laboratory and selected for their frequent use and material type. Location 1 was ceramic, location 2 was glass, location 3 was formica, and location 4 was leather.

Sampling, transport, storage

Sampling occurred early in the morning before routine activities, following the approach described by Fotsing Kwetché *et al*. [15]. A 25 cm² square sampling region was defined using a calibrated template. Samples were collected in triplicate per series: before decontamination, after cleaning (before disinfection), and 15 min following disinfectant application. The 15-minute interval followed manufacturers' recommendations and workflow considerations. For the leather surface, sampling occurred at 20 minutes because drying required additional time.

Each decontamination variant (Surfanios® 0.25% and sodium hypochlorite 0.12%) was tested across three series conducted on three consecutive days (one series per day). Immediately after collection, specimens were processed for laboratory analysis.

Bacteriological screening

Culture

Culturing followed the method of Fotsing Kwetché *et al*. [15], with minor adjustments. Each specimen was inoculated onto six agar plates (3 Eosin Methyl Blue Agar and 3 Mannitol Salt Agar plates). Incubation was carried out at 37 °C for four days. No dilution step was applied prior to inoculation.

Enumeration and identification

Once incubation produced bacterial growth, colony counting and identification were carried out using earlier methodological frameworks [13–16]. This involved visual assessment, microscopic examination, and a set of biochemical and enzymatic reactions to characterize the organisms of interest.

- *Macroscopic, microscopic, and enumeration*

After colonies developed, they were described according to visible traits such as tint, overall dimensions, outline, surface texture, clarity, and firmness. Gram-stained preparations were then viewed microscopically. During this descriptive step, each distinct colony type was quantified as CFU per Petri plate, following Fotsing Kwetché *et al.* [15]. Using the calibration formula established for surface-based bacterial counting [15], the actual bacterial loads (ABL) for Gram-positive cocci (GPC) and Gram-negative rods (GNR) were determined **(Table 2).** Calibration relied on S. aureus ATCC 29213 and E. coli ATCC 25922. Gram-positive rods (GPR) were estimated using the S. aureus curve due to envelope similarities. These reference organisms were used throughout for quality control.

Table 2. Features of the calibration curves and the analytical detection limit [15].

Bacterial Strain	Surface Material	Calibration Curve Equation*	R^2	95% Confidence Interval of Slope (a) and Intercept (b)	Detection Limit (CFU/cm²)
Escherichia coli ATCC 25922	Aluminum	ABL = 2.614 × 10³ × OBL + 2 × 10³	0.99924	a: [2.584 × 10³ – 2.644 × 10³] b: [−8 × 10³ – 12 × 10³]	7,228
	Ceramic	ABL = 400 × OBL + 63 × 10³	0.97667	a: [364 – 436] b: [−128 × 10³ – 254 × 10³]	63,800
	Formica	ABL = 161 × OBL + 32 × 10³	0.98504	a: [153 – 169] b: [−20 × 10³ – 84 × 10³]	32,322
	Glass	ABL = 180 × OBL + 4 × 10³	0.99691	a: [176 – 184] b: [−5 × 10³ – 13 × 10³]	4,360
	Leather	ABL = 721 × OBL + 7 × 10³	0.99342	a: [697 – 745] b: [−12 × 10³ – 26 × 10³]	8,442
	Sanded plywood	ABL = 33.5 × 10³ × OBL + 12 × 10³	0.98943	a: [32.1 × 10³ – 34.9 × 10³] b: [−63 × 10³ – 87 × 10³]	79,000
Staphylococcus aureus ATCC 29213	Aluminum	ABL = 261 × OBL + 302 × 10³	0.98793	a: [246 – 276] b: [−221 × 10³ – 825 × 10³]	302,522
	Ceramic	ABL = 3.13 × 10³ × OBL + 53 × 10³	0.98996	a: [2.99 × 10³ – 3.27 × 10³] b: [−230 × 10³ – 336 × 10³]	59,260
	Formica	ABL = 39 × 10³ × OBL + 782 × 10³	0.86131	a: [32 × 10³ – 46 × 10³] b: [−1118 × 10³ – 2682 × 10³]	860,000
	Glass	ABL = 1.73 × 10³ × OBL + 23 × 10³	0.99428	a: [1.66 × 10³ – 1.8 × 10³] b: [−404 × 10³ – 450 × 10³]	26,460
	Leather	ABL = 5.3 × 10³ × OBL + 587 × 10³	0.93152	a: [4.7 × 10³ – 5.9 × 10³] b: [−663 × 10³ – 1837 × 10³]	597,600
	Sanded plywood	ABL = 1.31 × 10³ × OBL + 826 × 10³	0.84549	a: [1.06 × 10³ – 1.56 × 10³] b: [−524 × 10³ – 2176 × 10³]	828,620

a ABL = actual bacterial loads (CFU/cm²); OBL = observed bacterial loads (CFU/cm²); 95%CI = 95% confidence interval; OBL = 40 × N / 25, where N is CFU/Petri dish; the factor 40 represents the extraction/inoculum volume ratio, and 1/25 converts counts from 25 cm² to 1 cm². b The analytical detection limit corresponds to 1 CFU per dish, approximately 2 CFU/cm² OBL.

- *Orientating tests for bacterial identification*

Microscopic appearance dictated the identification steps. For GPR and GNR, characterization remained limited to macro- and microscopic inspection. For GPC, a sequence of tests was performed, including catalase activity, mannitol use, free coagulase, DNase, and the Voges–Proskauer reaction.

Disinfectant susceptibility test

After isolates were identified, they were examined for their reaction to disinfectants in liquid medium. This assessment, linked to measured bacterial loads and known detection thresholds [15] **(Table 2)**, aimed at determining disinfectant activity.

- *Preparation of the bacterial suspension*

Each isolate was streaked on nutrient agar for 24 h to ensure purity. A suspension was then created by mixing colonies with 2 mL of sterile saline (0.9% NaCl) until reaching a turbidity equivalent to a 0.5 MacFarland standard. A 10 µL calibrated loop was used to make a "control streak" on nutrient agar.

- *Inoculation and incubation*

An aliquot of 100 µL (1.5×10^7 CFU) from the suspension was added aseptically to 500 µL of the disinfectant. This mixture was left at 26 °C for 15 min. Following that, triplicate streaks (10 µL each) were made on 55 mm Petri dishes with sterile loops, after which the plates were incubated aerobically at 37 °C for 24 h.

- *Reading and interpretation*

After the 24 h incubation, plates were examined for any growth on the test streaks. A disinfectant was interpreted as "effective" when it lowered viable bacteria to below a 5-log reduction [17], corresponding to <12 CFU in 10 µL from an initial 2.5×10^5 CFU. Absence of colonies on all three streaks meant the isolate was "susceptible"; visible colonies indicated "tolerance."

- *Sterility control for the disinfectants*

To confirm disinfectant sterility, 100 µL of each product was streaked onto 3 Eosin Methyl Blue plates and 3 Mannitol Salt Agar plates. Plates were kept at 37 °C for one week. With no colony growth, sterility (or absence of resistant contaminants) was validated.

Data analysis

Variables included the counts and categories of bacteria obtained from the work surfaces, measured surface loads, and the proportions of isolates classified as susceptible or tolerant to disinfectants. All data were processed in Microsoft Excel 2013, covering isolation frequencies, site-specific isolate numbers, computed ABL values, and disinfectant response rates.

Results and Discussion

Bacterial populations on the surfaces

Culturing of the sampled material yielded 184 isolates in total. These organisms fell into three main groups: Gram-positive cocci, Gram-positive bacilli, and Gram-negative bacilli. The overall proportions are shown in **Figure 1**, and the distribution by sampling area is listed in **Table 3.**

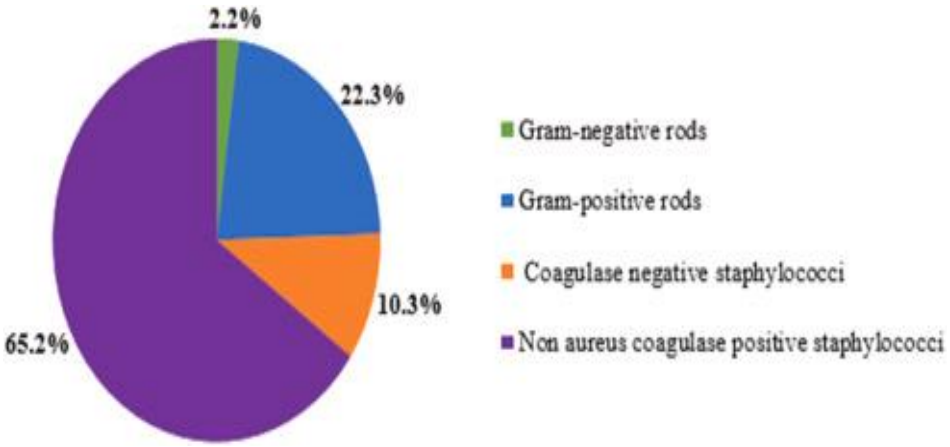

Figure 1. Overall distribution of bacterial isolates.

Table 3. Bacterial isolates were recovered from various work surfaces.

Decontamination Protocol	Sampling Location	Sampling Day	Gram-Negative Rods (GNR)	Gram-Positive Cocci in Clusters (GPC)[1]	Coagulase-Negative Staphylococci (CNS)	Non-aureus Coagulase-Positive Staphylococci (naCPS)[2]	Total Isolates

Surfanios® 0.25%	Location 1	Day 1	0	5	0	4	9
		Day 2	0	0	2	8	10
		Day 3	0	3	1	6	10
	Location 2	Day 1	0	6	1	2	9
		Day 2	1	1	1	8	11
		Day 3	0	0	1	10	11
	Location 3	Day 1	2	3	2	0	7
		Day 2	0	2	0	1	3
		Day 3	0	0	2	10	12
	Location 4	Day 1	1	1	0	6	8
		Day 2	0	0	0	4	4
		Day 3	0	0	0	1	1
Sodium hypochlorite 0.12%	Location 1	Day 1	0	0	0	5	5
(chlorinated water)		Day 2	0	2	0	7	9
		Day 3	0	1	1	2	4
	Location 2	Day 1	0	3	0	5	8
		Day 2	0	0	1	8	9
		Day 3	0	2	2	2	6
	Location 3	Day 1	0	2	1	11	14
		Day 2	0	4	0	10	14
		Day 3	0	2	1	1	4
	Location 4	Day 1	0	2	2	6	10
		Day 2	0	0	0	3	3
		Day 3	0	2	1	0	3

GNR: Gram-negative rods; GPR: Gram-positive rods; CNS: Coagulase-negative Staphylococcus; naCPS: non-aureus coagulase-positive Staphylococcus.

Location 1: Ceramic surface; Location 2: Glass surface; Location 3: Formica surface; Location 4: Leather surface.
The pattern in **Figure 1** indicates a markedly uneven composition, with Gram-positive organisms (97.8%) prevailing, particularly Staphylococcus spp. (75.5%). More than three-fifths of the isolates correspond to non-aureus coagulase-positive Staphylococcus. GPRs were recorded at roughly double the frequency of coagulase-negative Staphylococcus.
From **Table 3**, it is evident that the sites routinely host surface microbiota dominated by Staphylococcus, showing persistent daily representation of this group in the sampled areas.

Effect of decontamination on the bacterial loads
A summary of the changes in measured microbial densities during the hygiene procedure is presented in **Figure 2.**

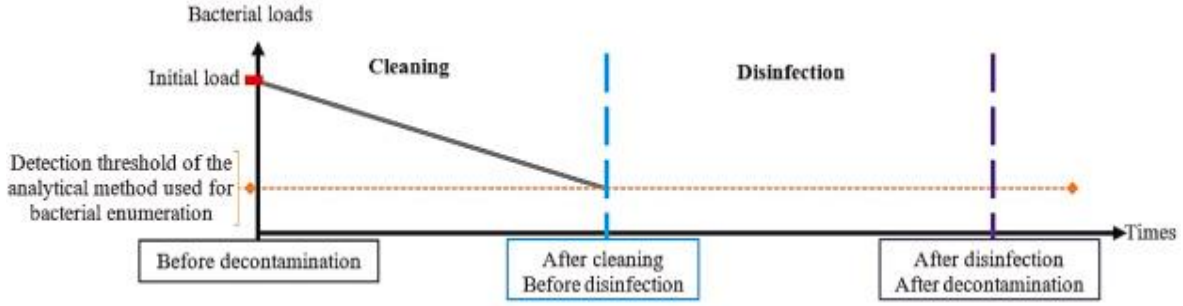

Figure 2. Overall variation in bacterial loads following decontamination.

According to **Figure 2**, the cleaning phase alone already produced a marked decline in detectable cells. Because post-cleaning levels dropped beneath the sensitivity limit of the analytical method, the graph further demonstrates that the final counts (post-decontamination) were clearly lower than those measured before any treatment. This confirms that the procedure reduced the microbial burden to non-detectable values.
Differences among sampling areas and taxonomic groups are outlined in **Table 4.**

Table 4. Evolution of bacterial loads during and after decontamination.

Surface treatment with 0.25% Surfanios®			
Day	**GPR**	**GNR**	**Staphylococcus spp.**
1	1.0308×10^5	ND	8.43×10^4
			ND indicates either no microbial presence (0 CFU/cm²) or levels below the detection capability of the surface-counting method.
2	ND	—	1.2812×10^5
3	1.2186×10^5	—	1.0934×10^5
Day	GPR	GNR	Staphylococcus spp.
1	6.106×10^4	ND	4.549×10^4
2	2.646×10^4	4.36×10^3	6.106×10^4
3	2.3×10^4	ND	6.798×10^4
Day	GPR	GNR	Staphylococcus spp.
1	1.406×10^6	3.9406×10^4	1.211×10^6
2	1.289×10^6	ND	8.6×10^5
3	ND	—	1.835×10^6
Day	GPR	GNR	Staphylococcus spp.
1	5.976×10^5	8.442×10^3	6.612×10^5
2	ND	ND	6.188×10^5
3	—	—	5.976×10^5
Surface treatment with 0.12% chlorinated water			
Day	**GPR**	**GNR**	**Staphylococcus spp.**
1	ND	ND	8.43×10^4
			ND signifies zero CFU/cm² or a quantity too minimal for the enumeration protocol to detect.
2	6.239×10^4	—	9.369×10^4
3	5.926×10^4	—	6.865×10^4

Day	GPR	GNR	Staphylococcus spp.
1	3.338×10^4	ND	5.587×10^4
2	ND	—	5.414×10^4
3	3.684×10^4	—	3.684×10^4
Day	**GPR**	**GNR**	**Staphylococcus spp.**
1	9.77×10^5	ND	1.796×10^6
2	1.094×10^6	—	1.64×10^6
3	8.99×10^5	—	9.77×10^5
Day	**GPR**	**GNR**	**Staphylococcus spp.**
1	6.029×10^5	ND	7.407×10^5
2	ND	—	6.135×10^5
3	6.029×10^5	—	5.976×10^5

GNR: Gram-negative rod; GPR: Gram-positive rod; ABL: actual bacterial load; ND: not detected; CFU: colony forming unit; bDe: before decontamination; aDe: after decontamination; bC: before cleaning; aC: after cleaning; bDi: before disinfection; aDi: after disinfection.

Location 1: Ceramic; Location 2: Glass; Location 3: Formica; Location 4: Leather.

Table 4 shows that, prior to treatment, the highest burdens occurred at locations 3 and 4, with locations 1 and 2 containing comparatively fewer organisms. Across all sites, Staphylococcus spp. represented the most substantial loads, followed by GPR. Regardless of surface type, both steps of the decontamination sequence consistently lowered the counts, often eliminating detectable colonies entirely.

Bacteria susceptibility to disinfectants

Findings from the disinfectant-susceptibility assessments are depicted in **Figure 3.**

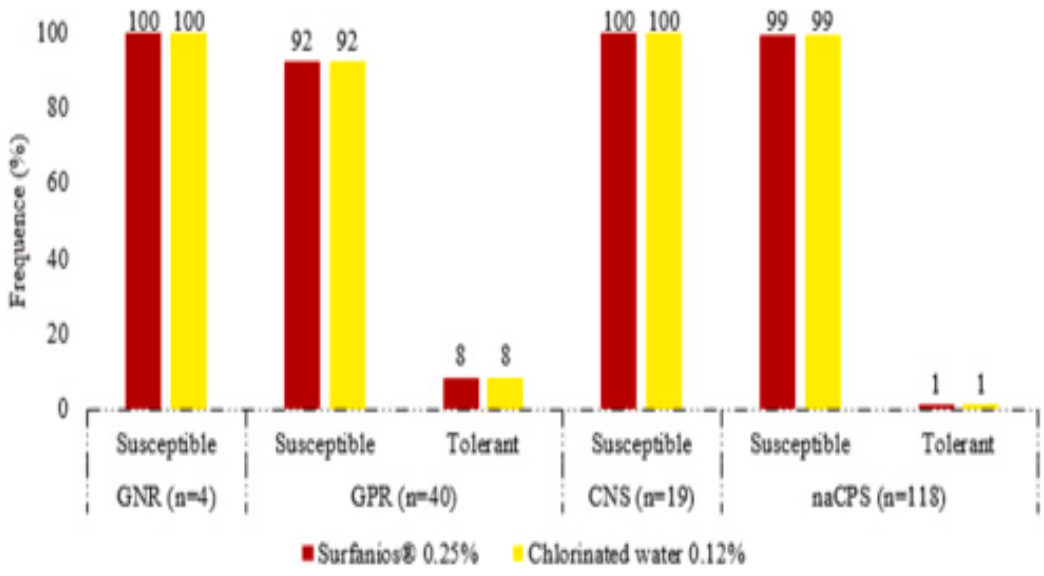

Figure 3. Disinfectant susceptibility trends per isolate category.

Overall, nearly all isolates tested exhibited sensitivity to both Surfanios® 0.25% and sodium hypochlorite 0.12% for the duration of exposure. Each agent achieved an effectiveness of 98%, and both produced nearly identical response profiles.

This study examined how well the UdMTH biomedical analysis laboratory's surface-care protocol performed. The investigation tracked reductions in microbial densities at several sites during and after the procedure, and also evaluated disinfectant responses.

Screening of collected material demonstrated that the work surfaces accommodated substantial numbers of microorganisms, mainly Gram-positive species—specifically Staphylococcus spp. (75.5%) and Gram-positive rods (22.3%)—while Gram-negative rods appeared only occasionally. Comparable patterns have been recorded at the same facility [8, 13, 14], in other hospitals [14, 18], and even in environments unrelated to healthcare, such as livestock operations [19]. Authors of those studies generally point to the durability of Gram-positive cell envelopes as a contributor to their environmental persistence, noting that they cope better with factors such as dryness and heat. Some GPR, including Bacillus spp., form spores, which further extend their survival under adverse conditions. Additionally, many of these organisms are facultative aerobes, enabling them to thrive with or without oxygen, thereby supporting their abundance across settings.

Considering the small proportion of GNR in this and similar studies [8, 13, 14], Staphylococcus spp. may serve as a practical microbial indicator of surface quality, especially where laboratory resources are restricted. Surface loads were globally elevated before decontamination, particularly at locations 3 (formica) and 4 (leather).

Results from the cleaning phase showed a substantial drop in microbial counts, consistent with prior work suggesting this mechanical step yields roughly 80% effectiveness [20]. From a microbiological standpoint, the removal of organic residues enhances the action of biocidal agents. In the present protocol, these were Surfanios® (a mixture including amino acids and quaternary ammonium compounds) and chlorinated water [20, 21]. Feliciano *et al*. similarly reported that organic debris can diminish the efficacy of sodium hypochlorite and quaternary ammonium disinfectants in food-processing contexts, using strains such as murine norovirus 1, E. coli ATCC 29181, and L. innocua ATCC 33090 [21].

Cleaning procedures also help remove microbial biofilms (when these layers are present on surfaces) and allow disinfectants to act more efficiently, recognizing that this type of microbial organization can hinder hygiene measures. The activity of disinfectants against biofilms depends on factors such as the active ingredient used, as well as the density and structure of the biofilm. Lineback *et al.* (2018) reported, for example, that hydrogen peroxide and sodium hypochlorite performed better against Staphylococcus aureus and Pseudomonas aeruginosa biofilms than quaternary ammonium compounds [22]. These considerations are dependable and can support adjustments of product volumes to ensure adequate cleaning and disinfection, preventing the application of concentrations lower than those specified by manufacturers. This avoids exposing bacteria to sub-inhibitory doses, which may promote the emergence of resistant variants, as shown by Condell *et al*. (2012) when individual chemical agents were examined. Conversely, those authors detected limited tolerance when strains were exposed to formulations combining multiple active substances derived from benzalkonium chloride (the main component of Surfanios®) [23].

Additional elements can also compromise hygiene practices, including reduced ambient temperatures, insufficient contact durations, and the use of porous materials. Therefore, specifying the appropriate temperature, exposure period, and surface type is essential when developing context-specific disinfection procedures [24].

Protocol performance may also be reduced if the water used is of poor quality—for instance, when it contains microorganisms or organic material. An assessment of water used in several healthcare centers in the Ndé Division (Western Cameroon) demonstrated that tap water at UdMTH was microbiologically acceptable [25].

The disinfectant susceptibility assays showed a high overall sensitivity (98%), indicating that Surfanios® (0.25%) and chlorinated water (0.12%) were effective against the tested bacterial isolates. Although bacterial survival after the cleaning phase could not be quantified due to the detection threshold of the analytic technique employed [15], the susceptibility patterns point toward successful disinfection. Because this study did not include a neutralizing agent—commonly added in some procedures—the susceptibility assay reflected disinfectant performance but did not fully isolate the effects of the 15-minutes disinfection stage. The absence of neutralization both before and during culture limited the assessment; however, the results can still be interpreted in light of the 15-minutes exposure and possible additional residual contact following the procedure.

This high susceptibility is consistent with the earlier discussion regarding the concentrations used during routine practice. Furthermore, Surfanios® and chlorinated water are generally not applied as antiseptics in this facility, as noted in previous publications [26], and when they are used for decontamination or surface treatment, the appropriate doses are respected by personnel. Rouillon *et al*. [26] recommended employing hospital-associated strains, such as Pseudomonas spp. and Acinetobacter spp., because of their properties and relevance in clinical environments [5–7, 26]. Consistent with the outcomes of this study, that recommendation will guide future research.

Although only a small fraction (2%) of isolates displayed reduced susceptibility to disinfectants, their detection highlights the importance of maintaining strict hygiene measures to limit the spread of resistance traits via mobile genetic elements. The laboratory where this work was carried out is regularly accessed by healthcare professionals with patient contact, making surveillance of potential cross-resistance between disinfectants and antibiotics essential—particularly for organisms like Pseudomonas spp. and Acinetobacter spp., which form part of the endogenous microbiota in healthcare settings [26]. Despite ongoing debates, cross-resistance is thought to arise when exposure to a disinfectant selects mechanisms that also defend against antimicrobial drugs—especially when both agents target similar cellular structures, share transport pathways, or rely on the same resistance determinants. It can also occur when genetic elements conferring tolerance to disinfectants and antibiotics coexist on the same mobile DNA. Efflux pumps are among the most frequently documented mechanisms explaining tolerance to disinfectants such as benzalkonium chloride [23].

A review of the susceptibility outcomes shows that Surfanios® at 0.25% and sodium hypochlorite at 0.12% are appropriate options for disinfection during decontamination and may also be rotated if needed. To preserve long-term efficacy, sectors such as food processing and particularly pharmaceutical manufacturing often advise periodically replacing the active disinfectants applied in facility decontamination to limit the emergence of tolerant strains. Nevertheless, Rouillon *et al*. reported that this rotation might not always be required, as they observed that Surfanios® maintained consistent activity against healthcare-associated strains over a ten-year period [26]. In contrast to chlorinated water, which functions solely as a disinfectant, Surfanios® provides both detergent and disinfecting actions, making it potentially more advantageous since its cleansing effect enhances the initial cleaning step and strengthens the subsequent antimicrobial activity.

However, considering accessibility and cost constraints, chlorinated water remains the most practical choice in many low-resource contexts worldwide.

In general, analysis of the results demonstrated that surface decontamination in the UdMTH Biomedical Laboratory was effective across all surface types, with glass being especially suitable due to its ease of handling within existing procedures. Furthermore, the findings indicate that even basic and inexpensive materials (Surfanios®, chlorinated water, tap water, and “Pax lemon” detergent) can be sufficient. Thus, adopting solutions that fit the local cost–benefit context is advisable.

Future studies should expand these observations to other microbial assemblages present in the work setting. Additionally, there is a need to determine alternative, context-specific microbial indicators for monitoring contamination or hygiene in environments with limited resources (as in this study). Research efforts should also aim to refine detection thresholds for surface microbial loads in support of sanitation-based hygiene evaluations.

Conclusion

This study showed that Staphylococcus was the dominant bacterial group on the sampled work surfaces. Microbial loads were elevated on all target areas before decontamination, but dropped below detectable levels after the “Pax lemon” detergent cleaning step. Most of the isolates were sensitive to Surfanios® (0.25%) and sodium hypochlorite (0.12%). Altogether, these results demonstrate that the procedures were effective for the bacteria investigated and support the application of Surfanios® (0.25%) or sodium hypochlorite (0.12%) for routine surface hygiene. In contexts similar to this one, using “Pax lemon” for cleaning followed by sodium hypochlorite for disinfection may be adequate for the types of surfaces included in this assessment.

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