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Bacteriological analysis on the faucet surfaces of public bathrooms in Goiânia, Goiás, Brazil

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Abstract

Microorganism transmission through direct or indirect contact, such as in public restrooms, is a significant concern in public health due to the potential for spreading infectious diseases. Faucet surfaces further increase the potential for cross-contamination, as they can harbor a considerable microbial load. In this context, this work randomly investigated the presence of bacteria on 150 different faucet surfaces of freely accessible public bathrooms in the central region of Goiânia, Goiás, Brazil, between August 2023 and February 2024. Results revealed that 100% of the faucets had manual operation. Additionally, more than one-third of the faucets in restrooms of Bars, Schools, Stores, Squares, Public Offices, Restaurants, and Bus Terminals were contaminated by bacteria with pathogenic potential, like coagulase-negative *Staphylococcus*, *Staphylococcus aureus*, *Streptococcus* sp, *Enterobacter* sp, *Escherichia coli*, *Pseudomonas* sp, *Serratia* sp, and *Shigella* sp. These findings shed light on the contamination chain, the urgency of sanitary measures by authorities, and the need for faucet automation.

Keywords: Bacterial transmission, faucet surfaces, public restrooms, Goiânia, Goiás, Brazil

Introduction

Hand hygiene is a historically significant topic in public health, with a development that dates back centuries [1]. Since early days of medicine, the importance of hand cleanliness in disease prevention has been recognized, although practices and methods have varied over time. Important advances were made in the late 19th century, when researchers like Ignaz Semmelweis and Joseph Lister began to promote handwashing as a crucial measure to reduce the spread of hospital infections. Subsequently, the discovery of germs by Louis Pasteur and the acceptance of microbial theories for diseases further solidified the importance of hand hygiene in the practice of health sciences [2]. From the 20th century onwards, with advances in microbiology and a deeper understanding of disease transmission mechanisms, more effective handwashing techniques were developed, along with the introduction of antiseptic agents [3]. Currently, hand hygiene is recognized as one of the simplest and most effective measures to prevent infections and communicable diseases, being widely promoted in healthcare settings and various society sectors [4].

Microorganisms transmission through direct or indirect contact, such as in public restrooms, is a significant concern in public health due to the potential for spreading infectious diseases. Hand hygiene and the implementation of rigorous cleaning protocols play a crucial role in preventing these infections [5]. Recent studies have investigated the mechanisms and factors that influence the transmission of bacteria, fungi, viruses, and protozoa in these environments [6].

The correlation between contaminated hands, microbial spread, and handling of flush handles, sinks, and doorknobs in bathrooms is a public health concern.

It is known that contaminated hands can serve as a vehicle for transferring a variety of pathogenic microorganisms, thus contributing to the spread of infectious diseases among these spaces users [7]. Faucets surface further increase the potential for cross-contamination, as these surfaces can harbor a considerable microbial load. This microorganisms' dissemination in public bathrooms can result in an increased risk of infections among these spaces users, underscoring the importance of hand hygiene as an essential preventive measure. Awareness of the need for proper hand hygiene practices and the implementation of rigorous cleaning protocols in public bathrooms are crucial for reducing the spread of infectious diseases and protecting public health [8]. Bacterial transmission in bathrooms reveals significant complexity in the types of bacteria present and potential consequences for human health. Studies highlight the prevalence of pathogenic organisms such as *Escherichia coli*, *Staphylococcus aureus*, and *Salmonella* sp, suggesting that these microorganisms can persist in moist environments and create favorable niches for proliferation [9]. These bacteria spread can occur through different pathways, including direct contact with contaminated surfaces, aerosols generated during toilet flushing, and even through airborne particles [10]. Bacterial dissemination increases the risk of gastrointestinal, respiratory, and skin infections, especially in environments where personal hygiene and proper cleaning are insufficient [11]. Understanding these transmission mechanisms and implementing effective hygiene measures are essential for mitigating health risks associated with the use of public and private bathrooms. In this context, this work aimed at investigating the presence of bacteria on the tap surfaces of freely accessible public bathrooms in the central region of Goiânia, Goiás, Brazil.

Methodology

This is a cross-sectional prevalence study conducted on freely accessible public restroom faucets in the central region of the municipality of Goiânia, Goiás, Brazil, between August 2023 to February 2024. Faucets from Bars, Schools, Stores, Squares, Public Offices, Restaurants, and Bus terminals were investigated. Due to the lack of standardization in the quantity of faucets distributed in public restrooms, sampling was defined as collecting from a single faucet in each restroom, chosen randomly, totaling 150 samples.

As experimental procedure, samples were collected in the afternoon by rubbing a sterile disposable swab moistened with sterile 0.9% saline solution on the upper surface of the faucet where contact with the user's hands occurs. Shortly after, the swab was placed into a test tube containing Stuart's transport medium, identified, and transported under refrigeration (4 °C to 8 °C) for inoculation at the Microbiology Laboratory of Alves Faria University Center (UNIALFA). There, following the methodology proposed by Murray *et al.* (2017) [12], samples were streaked onto Petri dishes containing two culture media, MacConkey agar and Blood agar, using the streaking technique. Plates were then incubated at 37 °C for 24 hours to analyze and identify positive cultures, and for those where no bacterial growth was observed, a further incubation at 37 °C for another 24 hours was performed.

After the incubation period, plates were properly wrapped with polyvinyl chloride (PVC) and transported to the Microbiology Laboratory at the State University of Goiás

(UEG - UnU Itumbiara) for morphological verification, Gram staining, and microscopic confirmation. For colonies with characteristics consistent with Gram-negative bacteria, in addition to Gram staining and analysis under a high-power optical microscope (1000x magnification), biochemical tests were performed using Triple Sugar Iron Agar (TSI); Simmons' Citrate Agar; Urea Broth; and Lysine Iron Agar (LIA), as well as Motility-Indole-Sulfide Medium (SIM) for detection of hydrogen sulfide production. For colonies resembling the genus *Staphylococcus*, Gram staining and microscopic confirmation (1000x magnification) were conducted, followed by catalase tests for differentiation between *Staphylococcus* and *Streptococcus*, and deoxyribonuclease (DNase) tests for distinguishing *Staphylococcus aureus* from coagulase-negative *Staphylococcus*.

Results were expressed as mean and as absolute and relative frequencies. Windows version of the GraphPad Prism 5.01 software was applied to perform statistical analysis. And, one-way ANOVA followed by Bonferroni post-tests with *p* values <0.05 were used.

Results

The first result revealed by the study was that all faucets (100%) had manual operation. Out of the 150 faucets analyzed, 58 were contaminated (38.66%) by at least one of 8 different genera, and in 17 faucets (29.31%), simultaneous presence of Gram-positive and Gram-negative bacteria was detected. Coagulase-negative *Staphylococcus* was identified in 19 different faucets (32.75%); *Enterobacter* sp in 13 faucets (22.41%), with *Enterobacter aerogenes* found in 9 (69.23%) and *Enterobacter gergoviae* in 4 (30.77%) faucet surfaces; *Staphylococcus aureus* and *Escherichia coli* were found in 7 faucets each (12.07%); *Streptococcus* sp represented 8.62% of the findings (n = 5); *Pseudomonas* sp, 5.17% (n = 3); *Serratia* sp were present in two faucets (3.45%), with 1 (50%) *Serratia liquefaciens* and 1 (50%) *Serratia marcescens*; and *Shigella* sp were found in two faucets (3.45%) (Table 1).

Table 1: Bacteria present on the surface of freely accessible public restroom faucets in the central region of Goiânia, Goiás, Brazil, between August 2023 to February 2024. Values expressed as absolute and relative frequencies. **p*<0.05 for all groups. One-way ANOVA and Bonferroni post-tests.

Bacterial agents*	N = 58	
	N	%
Gram-positive		
Coagulase-negative <i>Staphylococcus</i>	19	32.75
<i>Staphylococcus aureus</i>	7	12.07
<i>Streptococcus</i> sp	5	8.62
Gram-negative		
<i>Enterobacter</i> sp	13	22.41
<i>Escherichia coli</i>	7	12.07
<i>Pseudomonas</i> sp	3	5.17
<i>Serratia</i> sp	2	3.45
<i>Shigella</i> sp	2	3.45

Regarding the establishments, as described in Table 2, higher contamination was observed in restroom faucets at Bus Terminals (18 faucets, 31.03%) and Squares (16 faucets, 27.58%), followed by Bars (8 faucets, 13.79%); Restaurants (5 faucets, 8.62%); Stores (4 faucets, 6.89%); Public Offices (4 faucets, 6.89%); and Schools (3 faucets, 5.17%).

Table 2: Establishments that demonstrated positive bacterial contamination on the surface of freely accessible public restroom faucets in the central region of Goiânia, Goiás, Brazil, between August 2023 to February 2024. Values expressed as absolute and relative frequencies. * $p < 0.05$ for all groups. One-way ANOVA and Bonferroni post-tests

Public establishments*	N = 58	
	N	%
Bus Terminals	18	31.03
Squares	16	27.58
Bars	8	13.79
Restaurants	5	8.62
Stores	4	6.89
Public Offices	4	6.89
Schools	3	5.17

The information regarding the frequency of disinfection, as well as the products used for disinfection on the faucets of freely accessible public restrooms in the central region of the city of Goiânia, Goiás, Brazil, was sought, however, it was not precise. Overall, those who provided information reported that disinfection was carried out daily or even biweekly. The products applied for this purpose were said to be soap and detergent, disinfectant, and/or 70% ethanol. Thus, there were no significant differences in methods and products used for disinfection among the faucets allocated along public restrooms.

Discussion

Handwashing is recognized as a fundamental procedure in health promotion and prevention of both individual and collective infections [13]. This simple act, performed almost automatically, plays a crucial role in interrupting the transmission chain of various pathogens such as bacteria, fungi, viruses, among others [1, 14].

The faucet model commonly found in sanitary facilities can pose a significant challenge to maintaining hand hygiene. In most cases, these faucets require unwashed hands to operate them to obtain water, which can result in the transfer of contaminants to the faucet surface [15]. Studies have documented this concern, highlighting the potential for recontamination of freshly washed hands. Redway and Fawdar (2008) [16] demonstrated that faucets can act as reservoirs of bacteria and other pathogens, serving as a source of recontamination after handwashing. Michaud *et al.* (2012) [17] identified that hand contamination can persist after using conventional faucets, compromising hygiene efforts.

In this cross-sectional prevalence study conducted on freely accessible public restroom faucets in the central region of the city of Goiânia, Goiás, Brazil, between August 2023 to February 2024, it was observed that all faucets were only activated after manual contact by the user, which presumably suggests the transfer of contaminants possibly present on the hands to the faucet surface. After washing, the faucet was touched again to close it, compromising the quality of hygiene, as there would be a possibility of recontamination on the second contact. Seeking to investigate this hypothesis and provide qualitative data to assess the inquiry, the presence of bacterial agents on the faucet surface was verified and confirmed. More than one-third of the samples showed various bacteria with potential for intra and extra-intestinal pathogenicity, as well as indicators of contamination by intestinal organic matter.

The bacteria of the genus *Staphylococcus* sp and *Enterobacter* sp were the most prevalent, with these two accounting for two-thirds of the specimens' quantity found. The genus *Staphylococcus* sp is commonly identified as a contaminant of hands, representing a significant challenge for hygiene and public health. Recent studies have documented the presence of these bacteria on individuals' hands in different environments, including healthcare institutions, schools, and domestic settings. Chen *et al.* (2020) [18] identified *Staphylococcus aureus* as one of the main contaminants on healthcare professionals' hands, highlighting the importance of adopting rigorous hygiene practices to prevent the spread of nosocomial infections. Silva *et al.* (2020) [19] investigated the prevalence of *Staphylococcus epidermidis* on the hands of school-age children, emphasizing the importance of health education and proper hygiene practices from childhood to reduce the risk of *Staphylococcus* sp-related infections. Similarly, the genus *Enterobacter* sp represents a significant concern as a hand contaminant due to its capacity to cause serious infections, especially in healthcare professionals and hospitalized patients, highlighting its association with nosocomial infections. Saharman *et al.* (2021) [20] investigated the prevalence of *Enterobacter* sp as a hand contaminant among healthcare professionals in intensive care units, demonstrating its presence in a sizeable proportion of tested individuals. Similarly, Intra *et al.* (2023) [21] addressed the antimicrobial resistance of *Enterobacter* sp strains isolated from hospitalized patients, accentuating the importance of hand hygiene and infection control measures to prevent these pathogens spread. Other bacterial agents with potential infectious are described by studies in Brazil and internationally [7, 22-25], and were also identified on the surface of public restroom faucets in this study. Noteworthy are the Gram-positive Specimens *Streptococcus* sp; and Gram-negative *Escherichia coli*, *Pseudomonas* sp, *Shigella* sp, *Serratia liquefaciens*, and *Serratia marcescens*.

Regarding the seven groups of establishments evaluated, located in the central region of the city of Goiânia, Goiás, Brazil, bacterial contamination was observed on the surface of all public restroom faucets. The highest prevalence was observed in the faucets of Bus Terminals and Squares, which accounted for 58.61% of the total bacterial agents. Next, contaminated faucets were found in Bars (13.79%), Restaurants (8.62%), Stores (6.89%), Public Offices (6.89%); and finally, 5.17% of the contaminated faucet surfaces were in Schools ($p < 0.05$). Comparatively, numerous studies corroborate these findings regarding bacterial contamination in public environments. Ramlal *et al.* (2022) [26] investigated the presence of pathogenic bacteria in public restrooms at distinct locations, finding a high prevalence, especially on faucets and doorknobs. Semerjian *et al.* (2020) [27] analyzed bacterial contamination in commercial establishments, finding equivalent results to those observed in this study, confirming the need for control and prevention measures. Other studies, such as Matini *et al.* (2020) [28], also emphasized the importance of proper hygiene to prevent the spread of pathogens in public environments. Additionally, more recent research, such as that Iyo *et al.* (2022) [29] and Tadesse *et al.* (2023) [30], reinforce the relevance of the findings addressed here and the need for public policies aimed at ensuring sanitary safety in places of collective use.

In Brazil, sanitary regulations for public restrooms aim to ensure the health and safety of users, establishing specific guidelines for hygiene maintenance and disease prevention. At the national level, the Brazilian Health Regulatory Agency (ANVISA) is responsible for regulating sanitary conditions in places of collective use, including public restrooms, through Resolution RDC No. 50/2002^[31], which establishes criteria and procedures for the operation at these spaces. This resolution defines requirements such as the availability of potable water, adequate hygiene conditions, accessible sanitary facilities, and regular environments cleaning. Additionally, at the state level, in Goiás, the Superintendence of Health Surveillance (Suvisa) complements this regulation, adapting it to the local reality and overseeing compliance. These regulatory measures aim to promote the sanitary quality of public restrooms, ensuring a safe and healthy environment for all users, and contributing to the prevention of diseases transmitted by direct contact with contaminated surfaces. However, the data found in this research highlight the need for greater care and diligence from relevant authorities, as the presence of bacterial species was found in more than one-third of the evaluated faucets. Moreover, simultaneous presence of Gram-positive and Gram-negative bacteria was observed. Therefore, freely accessible public restrooms like those in the central region of Goiânia, Goiás, Brazil, require attention, considering the large flow of users who, by touching the faucet surface, are susceptible to bacterial contamination, making them sources and contributors to infections. One possible suggestion would be the automation of faucets, such as sensor-activated faucets or those with pedals.

Conclusion

It was observed that more than one-third of the evaluated faucets in freely accessible public restrooms of Bars, Schools, Stores, Squares, Public Offices, Restaurants, and Bus Terminals in the central region of Goiânia, Goiás, Brazil were contaminated by bacteria with pathogenic potential, both Gram-positive and Gram-negative. Results aim to shed light on the contamination chain, the urgency of sanitary measures by relevant authorities, and the need for faucet automation.

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Declaration of interest statement

Authors report no declarations of interest.

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