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Air Hand Dryers: A Potential Cause of Bacterial Contamination in Stand-Alone Fast-Food Restaurants

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Abstract. Using electrical air hand dryers in public spaces, including fast-food restaurants, may pose public health risks due to bacterial deposition. This study investigates the bacterial contamination caused by air hand dryers in wash areas and comfort rooms of freestanding fast-food restaurants. Using a descriptive-comparative approach, Petri dishes were exposed to air hand dryers for 30 seconds, incubated, and analyzed for bacterial growth. Six bacterial species were identified, with more diverse bacteria and higher deposition levels observed in wash areas compared to comfort rooms. This finding highlights the increased public health risks associated with air hand dryers in wash areas of fast-food establishments. It suggests the need for safer hand-drying alternatives in such settings.

Keywords: Air hand dryers; Bacteria deposition; Public health; Fast-food restaurants; Wash areas.

1.0 Introduction

Restaurants are vital in fostering communities' financial and social well-being (Feldman, 2015). Beyond their economic impact, restaurants serve as venues for convenience, enjoyment, and socialization, often attracting patrons seeking affordable and accessible dining experiences (Crinklaw, 2019). A survey by Vixxo (2019) revealed that 62% of Americans prefer dining in restaurants, compared to 34% who opt for takeout or delivery. On average, most restaurants serve 200 to 400 customers daily, with high-end establishments accommodating upwards of 1,000 patrons (Beck, 2022). Similarly, in the Philippines, nearly 46% of Filipinos dine in fast-food restaurants one to three times per week, highlighting this industry's cultural and economic prominence (The Most Popular Fast-Food Chains in the Philippines, 2020).

Given the significant risks of foodborne illnesses stemming from bacterial contamination, cleanliness, hygiene, and sanitation are pivotal factors in the restaurant industry (Klein, 2021). In the wake of the COVID-19 pandemic, public concern for hygiene, particularly in shared spaces such as public washrooms, has intensified (Donchak, 2020). While effective handwashing protocols—including wetting, lathering, scrubbing, rinsing, and drying—have been well-documented (Alharbi et al., 2015; CDC, 2021), proper hand drying remains underemphasized. Moist hands, which can harbor up to 1,000 times more bacteria than dry hands, significantly increase the risk of bacterial transmission (Lean, 2022; Huang et al., 2012). Wet hands also facilitate bacterial survival and spread from contaminated surfaces (Snelling et al., 2011).

The technological shift toward air hand dryers over paper towels in public and commercial spaces has been framed as an eco-friendly and cost-effective measure (Smith, 2018). However, emerging evidence challenges the safety of air hand dryers. Studies suggest that rather than mitigating bacterial contamination, these devices may exacerbate the problem by dispersing airborne microorganisms onto users' hands (Ross, 2018). Research by the University of Connecticut and Quinnipiac University found that hot-air hand dryers can deposit bacteria onto freshly washed hands, raising concerns about their efficacy compared to paper towels (Huang et al., 2012).

Despite these findings, the role of proper hand drying in infection control remains underrecognized, and misconceptions about the safety and effectiveness of air hand dryers persist. This oversight is concerning, as inadequate hand drying could negate the benefits of proper handwashing practices, particularly in high-risk settings like food service establishments. Although studies have highlighted the risks associated with air hand dryers, research gaps remain, particularly in comparing bacterial deposition across different settings, such as public wash areas versus private restrooms.

This study addresses these gaps by assessing bacterial deposition associated with air hand dryers in freestanding fast-food restaurants. This research aims to contribute to the growing body of evidence on hand hygiene practices by focusing on bacterial contamination in varied restroom environments. The findings are expected to inform restaurant hygiene protocols and public health guidelines, emphasizing the critical role of hand drying in preventing bacterial transmission and enhancing infection control measures.

2.0 Methodology

2.1 Research Design

This study used a quantitative descriptive-comparative research design, which involves gathering and comparing quantifiable and systemic data for the analysis. The researchers assessed the bacterial deposition of the air hand dryers utilized in the public wash areas and the comfort rooms of freestanding fast-food restaurants in Tacloban City. Bacterial colonies recovered were also identified.

2.2 Research Locale

Air hand dryers in public wash areas and comfort rooms of selected stand-alone fast-food restaurants in Tacloban City coded as fast-food A, B, C, D, and E were the target areas of this study. Convenience sampling was used to select the locale for this study. Through convenience sampling, the researchers could target five (5) freestanding Fast-food restaurants where the researchers conducted the study. The researchers opted for this type of sampling for only a limited number of stand-alone fast-food restaurants that were allowed to sample the hand dryers in their establishments.

2.3 Specimen Collection Procedure

Air hand dryers from public wash areas and fast-food A, B, C, D, and E comfort rooms assess bacterial deposition. Petri dishes with nutrient agar (NA) medium were exposed to the running air hand dryers 10 cm from the nozzle (Dawson et al., 2016) for 30 seconds (Kouadri, 2020). A nutrient agar medium will be appropriate for an open plate because it sustains the growth of a wide variety of bacterial species (Aryal, 2022). Furthermore, according to the study of Huesca-Espitia et al. (2018) and Alharbi et al. (2016), 30 seconds is the average time a person uses an air hand dryer to dry their hands. Mohammed (2021) also claimed that, on average, people place their hands 10cm away from the nozzle of air hand dryers when drying their hands. Agars were immediately covered, placed in a ziplock, and transported to the RTRMF laboratory using a disinfected plastic container. The NA plates were then incubated at 37°C for 24 hours.

2.4 Data Processing and Analysis

After incubating the NA plates, each bacterial colony on each plate was counted and evaluated according to their macroscopic morphology. Using a magnifying lens, the grown colonies were differentiated according to their margin, color, elevation, texture, shape, and size. Each unique colony was considered a distinct bacterial species. Hence, only a representative of the considered distinct bacterial species was tested for further bacterial identification.

Differential Staining (Gram Staining)
After identifying the isolates macro-morphologically, a bacterial smear was made from a representative of each type of colony identified on each NA plate.

a. A clean glass slide was passed over the flame 3-4 times, then laid on the table with the flamed side up to cool.
b. A drop of NSS was placed on the slide.
c. The inoculating loop was flame sterilized and then allowed to cool.
d. Using the flamed sterilized loop, the selected bacterial colony was lightly touched and emulsified in the drop of NSS on the slide to make a smear.
e. The smear was air dried, and heat was fixed by passing the underside of the smear over the flame 3 - 4 times. The smear was then let cool.

The smears were stained using the Gram staining method to differentiate the chemical and physical properties of the bacterial cell wall, the presence of spores, and their microscopic evaluation.

Biochemical Testing
After assessing the isolates through gram staining, biochemical tests were conducted for further identification based on their reactions and production of enzymes to certain tests. These biochemical tests include:

Catalase Test. This test is used to identify whether the bacteria produce the endoenzyme catalase. In this test, selected colonies from NA were emulsified with one drop of NSS and one drop of 3% H_2O_2. A catalase-positive test is indicated by bubble formation. The considered distinct bacterial species were reinoculated on blood agar plate (BAP), mannitol salt agar plate (MSA), and MacConkey agar plate (MAC) for further evaluation. The plates were then incubated at 37°C for 24 hours. After incubation, the bacterial colonies were evaluated depending on their growth and appearance on each agar. Grown colonies on BAP were evaluated according to the appearance of their hemolytic patterns. Since MSA is a selective media for the differentiation of staphylococci, grown colonies were evaluated according to the color change of the agar. A coagulase test was performed to confirm the differentiation of Staphylococcus aureus from the other staphylococci species.

Coagulase Test. This test is used to identify whether the bacteria produce the exoenzyme coagulase. Selected colonies from NA were emulsified in 1 drop of NSS and 1 drop of plasma. The presence of clumping or agglutination indicates a coagulase-positive test. The bacterial fermentation of lactose is being evaluated in MacConkey agar. Lactose-fermenting strains grow red or pink and may be surrounded by a zone of acid-precipitated bile. Lactose non-fermenting strains, such as Shigella and Salmonella, are colorless and transparent and typically do not alter the appearance of the medium. To further identify the grown colonies from the MAC agar, bacterial cultures were inoculated on Triple Sugar Iron Agar (TSIA) to determine the bacteria's ability to ferment glucose, lactose, and sucrose.

Sugar Fermentation. Using an inoculating needle, the assigned colony is stubbed into the butt of TSIA, and as the needle is removed, it is dragged in a zigzag pattern up the surface of the slant portion of the agar. Tubes were then incubated at 37°C for 24 hours for further identification of the grown colonies on TSIA, Indole test, Methyl red test, Voges-Proskauer test, and Citrate test (IMViC) were conducted. Using a flame-sterilize inoculating loop, grown colonies from TSIA were then inoculated into sulfide indole motility medium (SIM), into 2 MR-VP medium, and into simoun citrate medium.

Indole Test. Using a sterile inoculating needle, the selected colony was stabbed into the medium, and Ehrlich reagent was carefully added. The tube was made to stand for a few minutes. A purple ring in the junction of the medium and the reagent indicates a positive test for indole.

Methyl Red Test. Using a sterile inoculating needle, the selected colony was inoculated into one of the MR-VP mediums, and 10 drops of methyl red were added. The solution was mixed carefully. A positive test is indicated by red color, while a negative test is indicated by yellow color. This test determines if the bacteria produce stable acidic end-products through the mixed acid fermentation pathway.

Voges-Proskauer Test. Using a sterile inoculating needle the selected colony was inoculated into the other MR-VP medium; 1 ml of KOH was added. The solution was mixed thoroughly, and then 10 drops of alpha-naphthol were added drop by drop, shaking it slightly and letting it stand for 15 minutes. A positive test is indicated by red color. This test determines if the bacteria produce acetoin through the butylene glycol pathway.

Citrate Utilization. The selected colony was inoculated into Simoun Citrate medium using a sterile inoculating needle. A positive result is indicated by a change in color from green to blue. This test determines if an organism can grow aerobically using sodium citrate as its sole source of carbon and ammonium phosphate as its sole nitrogen source. For the final confirmation of the bacterial species, the researchers selected distinct bacterial colonies to be tested using the VITEK 2 machine.

2.5 Ethical Consideration

The researchers provided a formal permission letter to each involved stand-alone fast-food restaurant in Tacloban City and only conducted the sample collection with their approval. Strict coding was observed and done to ensure the ethical integrity of the fast-food restaurant involved in the study. The dissemination and communication of the study analysis, results, and discussion shall guarantee the confidentiality of the data and the establishments involved.

3.0 Results and Discussion

3.1 Cultural Characteristics of Bacterial Isolates Recovered

Since each unique colony was considered a distinct bacterial species, the researchers were able to select 18 unique bacterial species to be tested for further bacterial identification. Table 1 summarizes the appearances of the bacterial isolates' cultural characteristics on the respective agars, their gram staining characteristics, and from which restaurants the colonies were recovered.

Table 1. *Summary of cultural characteristics of the representative bacterial isolates recovered from nutrient agar plates*

Isolates	MAC	BAP	MSA	Gram Stain	Site
1	colorless	Gamma Hemolysis	No Growth	Gram (-) Bacilli	Fast-food E CR
2	colorless	Gamma Hemolysis	Red colonies with red zone	Gram (-) Bacilli	Fast-food E CR
3	No growth	Beta hemolysis	Red colonies with red zone	Gram (+) Bacilli	Fast-food E CR
4	No growth	Gamma Hemolysis	Yellow colonies with yellow zone	Gram (=) cocci in cluster	Fast-food E CR
5	Colorless	Gamma Hemolysis	No Growth	Gram (-) Bacilli	Fast-food C CR
6	No growth	Gamma Hemolysis	Red colonies with red zone	Gram (+) bacilli some with spores	Fast-food C CR
7	No growth	Gamma Hemolysis	Red colonies with red zone	Gram (+) bacilli	Fast-food C CR
8	No growth	Gamma Hemolysis	Red colonies with red zone	Gram (+) bacilli	Fast-food B CR
9	No Growth	Beta Hemolysis	Yellow colonies with yellow zone	Gram (+) cocci in cluster	Fast-food B CR
10	Colorless	Gamma Hemolysis	Red colonies with red zone	Gram (-) bacilli	Fast-food B CR
11	Colorless	Gamma Hemolysis	Red colonies with red zone	Gram (-) bacilli	Fast-food B CR
12	No growth	Gamma Hemolysis	Yellow colonies with yellow zone	Gram (+) bacilli	Fast-food B Wash Area
13	Colorless	Gamma Hemolysis	No Growth	Gram (-) Bacilli	Fast-food B Wash Area
14	No Growth	Gamma Hemolysis	Yellow colonies with yellow zone	Gram (+) bacilli in chain	Fast-food C Wash Area
15	No Growth	Gamma Hemolysis	Yellow colonies with yellow zone	Gram (+) bacilli	Fast-food B Wash Area
16	No Growth	Beta Hemolysis	Yellow colonies with yellow zone	Gram (+) cocci in cluster	Fast-food A Wash Area
17	No Growth	Beta Hemolysis	Yellow colonies with yellow zone	Gra (+) Bacilli in chain with pores	Fast-food A Wash Area
18	Colorless	Gamma Hemolysis	Red colonies with red zone	Gram (+) cocci	Fast-food D Wash Area

It can be observed in Table 1 that on MAC, only isolates 1, 2, 5, 10, 11, and 13 showed growth and appeared colorless, hence identifying them as non-lactose fermenters. In contrast, the remaining isolates did not grow on the said medium. On BAP, isolates 3, 9,16, and 17 exhibited a Beta hemolytic pattern; the other isolates all showed a Gamma hemolytic pattern, and none were alpha-hemolytic bacteria. The isolates that showed a positive result on MSA are 2, 3, 6, 7, 10, 11, and 18. Isolates 1, 5, and 13 showed no growth on the said medium, and the rest of the colonies showed negative results. Isolates 1, 2, 5, 10, 11, and 13 exhibited as gram-negative bacilli; isolates 3, 6, 7, 8, 12, 14, and 17 exhibited as gram-positive bacilli; and isolates 4, 9, and 18 showed to be gram-positive cocci.

3.2 Biochemical Tests Results

The following tables show the summary of biochemical test results of the representative isolates. As gleaned in Table 2, all isolates were catalase-positive, and only isolates 9 and 16 were coagulase-positive. Isolates that grew on MAC agar (isolate 1, 2, 5, 10, 11, and 13) were further tested for sugar fermentation on TSIA; all isolates showed an Alkaline over Alkaline result indicating the absence of carbohydrate fermentation. The isolates from TSIA were reisolated for further bacterial identification to IMViC media, where isolates 1, 2, 5, 10, 11, 13, and 18 showed

negative results for Indole, Methyl Red, and Voges Proskauer. In Simoun Citrate, only isolate 18 showed a negative result, whereas the other 6 showed a positive result. For the final bacterial species identification, the researchers utilized the VITEK 2 compact machine of the Eastern Visayas Medical Center (EVMC) Laboratory. However, not all 18 isolates were submitted for testing due to financial limitations. Only the isolates the researchers' manual testing cannot confidently identify were sent to be identified by the machine.

Table 2. *Summary of the biochemical tests results of the representative bacterial isolates*

Isolates	Catalase	Coagulase	TSIA	Indole	Methylred	Voges Proskauer	Simoun Citrate
1	+	-	K/K (-) H2S (-) Gas	-	-		+
2	+	-	K/K (-) H2S (-) Gas	-	-	-	+
3	+	-					
4	+	-					
5	+	-	K/K (-) H2S (-) Gas	-	-	-	+
6	+	-					
7	+	-					
8	+	-					
9	+	+					
10	+	-	K/K (-) H2S (-) Gas	-	-	-	+
11	+	-	K/K (-) H2S (-) Gas	-	-	-	+
12	+	-					
13	+	-	K/K (-) H2S (-) Gas	-	-	-	+
14	+	-					
15	+	-					
16	+	+					
17	+	-					
18	+	-					

3.3 Bacterial Identification

Table 3 reveals the final bacterial species identification of each representative isolate.

Table 3. *Final bacterial species identification*

Isolate	Species
Isolate 1	*Pseudomanas stutzeri*
Isolate 2	*Acinetobacter baumannii*
Isolate 3	*Bacillus spp*
Isolate 4	*Staphylococcus sciuri*
Isolate 5	*Pseudomanas stutzeri*
Isolate 6	*Bacillus spp*
Isolate 7	*Bacillus spp*
Isolate 8	*Bacillus spp*
Isolate 9	*Staphyloccus aureus*
Isolate 10	*Acinetobacter baumannii*
Isolate 11	*Acinetobacter baumannii*
Isolate 12	*Bacillus spp*
Isolate 13	*Pseudomanas stutzeri*
Isolate 14	*Bacillus spp*
Isolate 15	*Bacillus spp*
Isolate 16	*Staphyloccus aureus*
Isolate 17	*Bacillus spp*
Isolate 18	*Staphylococcus hominis*

Isolate 1, 5, and 13 were confirmed to be *Pseudomonas stutzeri*; Isolate 2, 10, and 11 were confirmed to be *Acinetobacter baumannii*; Isolate 4 was confirmed to be *Staphylococcus sciuri*; Isolate 9 and 16 were confirmed to be *Staphylococcus aureus*; Isolate 18 was confirmed to be *Staphylococcus hominis*; and the rest of the isolates (3, 6, 7, 8, 12, 14, 15, and 17) fall under Bacillus spp. Identifying bacterial species in air hand dryers within fast-food restaurant wash areas and comfort rooms suggests these devices may contribute to spreading harmful bacteria, including *Acinetobacter baumannii* and *Staphylococcus aureus*. Instead of promoting hygiene, air hand dryers might

disperse bacteria onto hands and surrounding surfaces, potentially increasing the risk of infection. This highlights the need for improved design, maintenance, and possibly reconsideration of air hand dryers in public restrooms to ensure they do not become vectors for contamination, particularly in high-traffic areas.

3.4 Bacterial Species Distribution

The table below shows the distribution of all bacterial species isolated from the hand dryers in selected standalone fast-food restaurants to summarize where the bacterial species were present. As reflected in Table 4, *Acinetobacter baumannii* was only deposited by the hand dryer in the comfort room of fast-food B. Bacillus spp, and *Staphylococcus aureus* present in both wash areas and comfort rooms of all fast-food restaurants, making these species the most isolated bacterial species. *Pseudomonas stutzeri* were found in wash areas of Fast-food A,B,C. *Staphylococcus hominins* were only present in the wash area of Fast-food D. At the same time, *Staphylococcus sciuri* was present only in the wash area of Fast-Food E. Hence, the air hand dryers in wash areas deposited more variety of bacterial species than those inside the comfort rooms.

Table 4. *Distribution of bacterial species isolated from air hand dryers in wash areas and comfort rooms*

Bacteria	Fast-food A		Fast-food B		Fast-food C		Fast-food D		Fast-food E	
	CR	*WA*	*CR*	*WA*	*CR*	*WA*	*CR*	*WA*	*CR*	*WA*
A. baumannii			+							
Bacillus spp.	+	+	+	+	+	+	+	+	+	+
P. stutzeri		+		+		+				
S. aureus	+	+	+	+	+	+	+	+	+	+
S. hominis								+		
S. sciuri										+

Note: WA - Wash Area; CR - Comfort Room

3.5 Frequency Distribution of Bacterial Colony

Table 5 shows the frequency distribution of bacterial colonies recovered from the comfort rooms among Fast-food restaurants. It is observed that *S. aureus* is the most distributed species, compromising about 77.61% of the overall bacterial colonies. Followed by Bacillus spp. with a total of 107 colonies, approximating 21.02% of the overall bacterial colonies. *A. baumannii* only approximated 0.78%, having four colonies. The last species recovered from the samples from the comfort rooms is *P. stutzeri*, having only three colonies and approximating 0.59% - the least commonly distributed bacterial species. Meanwhile, *S. hominis* and *S. sciuri* were not recovered in the samples from the comfort rooms.

Table 5. *Frequency distribution of bacterial colonies from the comfort rooms*

Species	Frequency	Percentage
Acinetobacter baumannii	4	0.78
Bacillus spp	107	21.0
Pseudomonas stutzeri	3	0.59
Staphylococcus aureus	395	77.6
Staphylococcus hominis	-	
Staphylococcus sciuri	-	

Table 6 shows the frequency distribution of bacterial colonies recovered from the wash areas of the fast-food restaurants. It is observed that *S. aureus* is still the most distributed, compromising about 91% of the overall bacterial colonies. Followed by Bacillus spp. with a total of 56 colonies, approximating 7% of the overall bacterial colonies. *S. hominis* colonies totaled 8, which compromised to only 1%. *P. stutzeri* totaled to 5 colonies, approximating to only 0.6%. *S. sciuri* was the least commonly distributed colony, with only one colony recovered – approximating 0.1%. Meanwhile, *A. baumanni* was not recovered in any sample from wash areas of all selected freestanding Fast-food restaurants.

Table 6. *Frequency distribution of bacterial colonies from the wash areas*

Species	Frequency	Percentage
Acinetobacter baumannii	-	-
Bacillus spp	56	6.96
Pseudomonas stutzeri	5	0.62
Staphylococcus aureus	734	91. 2
Staphylococcus hominis	8	0.99
Staphylococcus sciuri	1	0.12

The data indicate a high level of bacterial contamination in fast-food restaurants' comfort rooms and wash areas, with *Staphylococcus aureus* being particularly prevalent. This underscores the need for improved sanitation

practices to reduce bacterial load and minimize the risk of infection. The presence of other potentially harmful bacteria, even in smaller quantities, further highlights the importance of maintaining strict hygiene standards in these public spaces. Future studies might evaluate the effectiveness of different cleaning protocols and explore innovative approaches to disinfect these environments more thoroughly.

Table 7. *Frequency distribution of the total bacterial colonies*

Species	Frequency	Percentage
Acinetobacter baumannii	4	0.30
Bacillus spp	163	12.0
Pseudomonas stutzeri	8	0.60
Staphylococcus aureus	1129	86.0
Staphylococcus hominis	8	0.60
Staphylococcus sciuri	1	0.10

3.6 Clinical Significance of the Identified Bacterial Species

To provide additional insights, the table below shows the clinical significance of each bacterial species isolated from the air hand dryers of the selected stand-alone fast-food restaurants. It is shown that all the identified bacterial isolates are widely found in the environment.

Table 8. *Clinical significance of the bacterial isolates from the air hand dryers*

Bacterial Species	Clinical Significance
Acinetobacter baumanni	A ubiquitous gram-negative coccobacillus, which is an opportunistic pathogen and is considered a major cause of nosocomial infections. *A. baumannii* can cause septicemia, urinary tract infection, pneumonia, and can infiltrate open wounds (Nocera et al., 2021). It is also considered a multi-drug-resistant bacteria (Sasidhar, 2018).
Bacillus spp.	Bacillus spp. are aerobic spore-forming rods that have been known to cause extensive infections such as abscesses, septicemia, endocarditis, meningitis, ophthalmitis, osteomyelitis, peritonitis, and respiratory and urinary tract infections. Most of these manifest as secondary infections affecting immunocompromised hosts. Species often associated with these types of infection are *B. cereus*, *B. licheniformis,* and *B. subtilis.* Meanwhile, *B. alvei, B. brevis, B. circulans, B. coagulans, B. macerans, B. pumilus, B. sphaericus,* and *B. thuringiensis* only cause infections occasionally (Turnbull, n.d.).
Pseudomonas stutzeri	A gram-negative bacillus that is widely distributed in the environment. Compared to other Pseudomonas species, *P. stutzeri* is rarely reported as a causative agent of infective endocarditis. However, it has been reported to be an opportunistic pathogen in humans, causing pneumonia, meningitis, ocular infection, bacteremia, osteomyelitis, and joint infections (Alwazzeh et al., 2020).
Staphylococcus hominis	A gram-positive coagulase-negative cocci occurs as a normal flora on human skin. *S. hominis* rarely causes endocarditis and has been isolated as a presumed pathogen in skin and soft tissue infection (Uddin et al., 2022).
Staphylococcus sciuri	A gram-positive coagulase-negative cocci isolated from animals, humans, and various food products. *S. sciuri* is an opportunistic pathogen that is a causative agent of endocarditis, peritonitis, septic shock, urinary tract infection, pelvic inflammatory disease, and wound infections (Naik et al., 2018).

Detection of bacterial species from air hand dryers suggests that these devices act as reservoirs for the accumulation and spread of microorganisms due to regular usage by individuals. This makes all, healthy or unhealthy, symptomatic or asymptomatic, contribute to the distribution of bacteria around the environment, including those that carry pathogenic risks (Suen et al., 2019). The presence of these bacteria is due to several users' activities in wash areas and comfort rooms. For instance, *Staphylococcus aureus* might have spread from shed skin microbiota or could be released from the respiratory tract by coughing and sneezing of people or from discharged sputum (Mohammed, 2021). Bacillus spp. was also present, as it could have spread through individuals' soil-contaminated footwear. *Pseudomonas stutzeri* is also present and has most likely spread from wounds, respiratory tract, and urine (Mohammed, 2021). Furthermore, *Staphylococcus hominis* is present and might have spread through the shedding of the skin as it is commonly isolated from human skin (Severn et al., 2022). Since it can be isolated from these, *Staphylococcus sciuri* might have been spread from various food products (Naik et al., 2018). In addition, the presence of *Acinetobacter baumannii* may result from respiratory tract secretions (Kandi et al., 2016). They could also be transmitted from the mucosa of the digestive and urinary tracts of infected or even healthy people, resulting from skin shedding (Mao Chem et al., 2015). All these bacteria circulate in the environment and are picked up by a functioning hand dryer.

In the data gathered, *S. aureus* is the most isolated bacteria and is found to be present in both wash area and comfort room air hand dryers from all selected fast-food restaurants; this is also consistent in the study of Huesca-Espitia et al. (2018) and Pernell et al. (2018). The recovery of bacilli spp in this study was only generalized because the VITEK 2 compact machine does not identify specific species of bacilli. The bacilli spp recovered by the other studies conducted are as follows: *B. subtilis* (Huesca-Espitia et al., 2018), *B. cereus* (Alharbi et al. 2016 and Vardoulakis et al., 2022); Lactobacilli (Wilcox et al. (2014); *B. infantis, B. licheniformis, B. marisflavi, B. megaterium, B. pumilus, B. simplex* (Vardoulakis et al., 2022). In this study, the recovered species under Pseudomonas spp were P. stutzeri. Meanwhile, other studies recovered *P. alcaligenes* (Alharbi et al., 2016), *P. aeruginosa* (Kouadrı, 2020), and

P. luteola (Huesca-Espitia et al., 2018). The isolation of *Staphylococcus hominis* is also consistent with the study conducted by Huesca-Espitia et al. (2018). Other studies have not recovered *Staphylococcus sciuri* from air hand dryers; this might be because it is more common in settings with livestock (Kengkoom & Ampawong, 2017). The recovery of *Acinetobacter baumanni* from air hand dryers is also consistent with the study of Huesca-Espitia et al. (2018) and Mohammed (2021).

Several factors, such as poor hygiene measures, inadequate ventilation, and warm and wet environment, can allow microorganisms to thrive and survive for a long time on surfaces and items around the area. Rubbish bins placed in the toilet are a potential source of the spread of microorganisms (Mohammed, 2022). Some species that are isolated may be in danger to susceptible individuals. Several factors also affect bacterial distribution from air hand dryers to the hands of the user. These factors include the type of electric dryer, frequent dryer use, exposure period to the blowing air, type of bacterial species, and the number of diffused bacterial cells (Suen et al., 2019). Furthermore, according to the results in the previous tables, hand dryers found in wash areas of fast-food restaurants deposit more variety of bacterial species compared to the hand dryers found inside the comfort rooms. This can be because more people use air hand dryers in wash areas rather than in comfort rooms. Since these air hand dryers are placed in a more open space, it is more convenient for individuals to use the device, and they will no longer need to use or choose hand dryers inside comfort rooms.

4.0 Conclusion

The data gathered revealed that the air hand dryers utilized by selected Fast-food restaurants deposit bacteria, and some may carry pathogenic risks. The data also showed a difference in the distribution of bacteria by air hand dryers in wash areas and comfort rooms. In the final identification, the researchers isolated a total of 6 bacterial species. These species isolated were *Acinetobacter baumannii, Bacillus spp., Pseudomonas stutzeri, Staphylococcus aureus, Staphylococcus hominis,* and *Staphylococcus sciuri*. Hence, it can be concluded from the data gathered from this study that the hand dryers in the wash areas of fast-food restaurants deposit more variety of bacterial species and colonies compared to those inside the comfort rooms. This can be because more people utilize the air hand dryers in the wash area and open spaces in fast-food restaurants.

Staphylococcus aureus is the most isolated bacteria and is found to be present in both wash areas and comfort room air hand dryers from all selected stand-alone fast-food restaurants. *Pseudomonas stutzeri*, on the other hand, is consistently distributed only by air hand dryers in wash areas. Potential human pathogens such as *P. stutzeri* and *A. baumanni* were also isolated. When air hand dryers are used, these microorganisms can be inhaled by people, contaminated, and distributed to the environment. In addition to investigating the types of pathogenic microorganisms dispersed by air dryers, the results of this study increase concerns about hand drying facilities in wash areas and comfort rooms to prevent contamination of washed hands and environments by pathogenic bacteria.

5.0 Contribution of Authors

All authors contributed significantly to this research. Authors 4 and 5 were responsible for the study's conception and design. Authors 1 and 2 conducted the data analysis and interpretation. Authors 3 and 6 played a key role in drafting the manuscript, while Author 1 provided critical revisions and final approval of the version to be published. All authors have read and approved the final manuscript.

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7.0 Conflicts of Interest

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8.0 References

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