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Microbiological Contamination and Antibiogram of *Staphylococcus aureus* Isolated from Fomites in Commercial Food Service Establishments in Ipetumodu, Southwestern Nigeria

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Abstract

Foodborne illnesses transmitted via environmental fomites in food service settings represent a critical public health concern in developing regions. This study evaluated the microbiological contamination and antimicrobial resistance profiles of bacterial isolates recovered from high-touch contact surfaces (dining tables, door handles, and serving points) across five selected commercial restaurants (comprising modern and local establishments) in Ipetumodu, Southwestern Nigeria. A total of 20 swab samples were collected aseptically across two sampling days and analyzed using standard microbiological protocols. Bacterial isolation was performed on Mannitol Salt Agar and Nutrient Agar, followed by phenotypic characterization using Gram staining and key biochemical assays (catalase, coagulase, citrate utilization, indole, methyl red, and Voges-Proskauer tests). Out of the 20 sampled surfaces, 19 (95.0%) yielded positive cultures for *Staphylococcus aureus*, whereas 1 (5.0%) was identified as *Pseudomonas aeruginosa*. Antimicrobial susceptibility testing executed via the Kirby-Bauer disc diffusion method against seven conventional antibiotics revealed that all 19 *S. aureus* isolates displayed complete resistance to Ceftazidime (100.0%), Cefuroxime (100.0%), and Augmentin (100.0%), alongside substantial resistance to Gentamicin (78.9%), Erythromycin (68.4%), Ofloxacin (63.2%), and Ciprofloxacin (57.9%). The high bacterial prevalence and predominant multidrug-resistant phenotypical patterns emphasize that environmental contact surfaces serve as active vectors for pathogen persistence and cross-transmission. These findings underscore an urgent need for mandatory implementation of rigorous sanitation regimens, routine hygiene monitoring, and the Hazard Analysis Critical Control Point (HACCP) framework in food establishments to mitigate microbial transmission risks.

Keywords: *Staphylococcus aureus*; Food contact surfaces; Fomite transmission; Antimicrobial resistance; Restaurant hygiene; Public health.

1. INTRODUCTION

Access to microbiologically safe food is essential for human health, economic stability, and quality of life (Lund and O'Brien, 2009). Globally, foodborne diseases cause over 600 million illnesses and 420,000 deaths annually, posing significant threats in developing nations where inadequate sanitary infrastructure and poor environmental hygiene exacerbate pathogen exposure (WHO, 2015). In Nigeria, rapid urbanization has heightened reliance on commercial eateries and restaurants for daily meal consumption (Knight et al., 2007).

Beyond undercooked raw ingredients, environmental cross-contamination via inanimate contact surfaces (fomites) is a key driver of pathogen transmission (Collins, 2007). High-touch restaurant surfaces such as dining tables, food serving counters, and entry door handles frequently collect organic residues when uncleaned, forming conditioning films that foster bacterial survival and biofilm development (Evans et al., 1998; Whitehead and Verran, 2010; Myszka and Czaczyk, 2011).

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Among surface contaminants, *Staphylococcus aureus* is a pathogen of major public health concern (Lowy, 1998; Kadariya et al., 2014). As a facultative anaerobic Gram-positive coccus asymptomatically colonizing 20% to 30% of human skin and nares, S. aureus is readily transferred to restaurant fomites by food handlers via unwashed hands or respiratory droplets (Lowy, 1998; Tebbutt et al., 2007). Besides causing enterotoxin-mediated food poisoning, the emergence of multidrug-resistant (MDR) S. aureus phenotypes driven by widespread misuse of beta-lactams, macrolides, and fluoroquinolones turns contact surfaces into persistent reservoirs for cross-infection (Plata et al., 2009; Nguyen and Tallent, 2019).

Despite these risks, empirical data on the microbiological load and antibiograms of surface contaminants in semi-urban Nigerian communities remain limited. This study was therefore conducted to isolate, phenotypically characterize, and determine the antimicrobial resistance profiles of bacterial contaminants specifically Staphylococcus aureus on high-touch surfaces in commercial restaurants in Ipetumodu, Osun State, Nigeria.

1.2 Statement of the Research Problem

Foodborne disease outbreaks originating from commercial eateries continue to pose severe threats to consumer health and national economic productivity. In many semi-urban commercial centers, food safety assessments rely almost exclusively on visual cleanliness, which is a poor indicator of microbiological quality. High-touch surfaces such as dining tables, serving counters, and entrance door handles come into direct and indirect contact with ready-to-eat foods and human hands. If these surfaces are improperly cleaned or sanitized using contaminated cloths, they act as silent vectors for pathogenic microflora. Furthermore, the expanding global threat of antimicrobial resistance means that surface contaminants are increasingly resistant to standard therapeutic antibiotics, elevating the risk of severe, treatment-impervious foodborne infections.

1.5 Research Questions

i. What are the physical and visual sanitary conditions of commercial restaurants in Ipetumodu, and what is the prevalence and distribution of bacterial species contaminating their contact surfaces?
ii. What are the phenotypic morphological, biochemical, and antimicrobial resistance (MDR) characteristics of bacterial pathogens (specifically *Staphylococcus aureus*) isolated from dining tables, door handles, and serving points?

1.3 Objectives of the Study

i. Assess the physical and visual sanitary conditions and sample critical high-touch contact surfaces (dining tables, entrance door handles, and food serving counter points) across selected commercial restaurants in Ipetumodu.
ii. Isolate, phenotypically characterize, and determine the antimicrobial susceptibility and multidrug resistance (MDR) profiles of the bacterial contaminants (specifically *Staphylococcus aureus*) against commonly prescribed therapeutic antibiotics.

2. LITERATURE REVIEW

2.1 Dynamics of Food Contact Surface Contamination

In food service environments, solid surfaces are continually exposed to organic soil, dust, food residues, and human secretions. Organic matter deposited on surface matrices acts as a conditioning film, providing essential nutrients that support microbial survival, attachment, and

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proliferation (Whitehead and Verran, 2010). Upon attachment to inanimate surfaces, bacteria synthesize extracellular polymeric substances (EPS) that anchor cells together, forming structured microcolonies that can mature into resilient biofilms (Myszka and Czaczyk, 2011). Cross-contamination occurs when bacterial pathogens attached to fomites are transferred to clean food items, kitchen utensils, or human hands during food preparation and consumption (Tebbutt et al., 2007).

2.2 Significance of Sanitary Food Contact Surfaces in Public Health

Cross-contamination via contaminated food preparation and serving surfaces is incriminated in nearly 80% of reported commercial foodborne illness outbreaks (Collins, 2007). Factors contributing to high microbial loads on food premises include inappropriate hot/cold holding temperatures, poor personal hygiene of food handlers, and ineffective cleaning regimens (Lund and O'Brien, 2009). Relying solely on visual evaluation for surface cleanliness is highly deceptive; surfaces that appear visually spotless may harbor dense populations of pathogenic bacteria (Moore and Griffith, 2002; Tebbutt et al., 2007). Microbiological surveillance of surface hygiene is therefore essential for validating sanitation routines and preventing outbreaks in catering operations (Verran et al., 2012).

2.3 Foodborne Bacterial Pathogens

Staphylococcus aureus is a leading cause of gastroenteritis resulting from the ingestion of pre-formed thermostable enterotoxins (Lowy, 1998; Kadariya et al., 2014). S. aureus strains produce multiple virulence factors, including proteases, lipases, hyaluronidases, and superantigenic enterotoxins that resist heat, freezing, and proteolytic digestion in the digestive tract (Kadariya et al., 2014). Furthermore, strains possessing the mecA gene code for altered penicillin-binding protein 2a (PBP2a), imparting resistance to beta-lactam antibiotics and leading to methicillin-resistant S. aureus (MRSA) strains of public health concern (Lowy, 1998).

Escherichia coli strains are Gram-negative bacilli within the family Enterobacteriaceae. While most commensal strains harmlessly inhabit the gut, pathogenic variants such as enterohemorrhagic E. coli (EHEC) O157:H7 produce potent Shiga toxins (Stx1/Stx2) (Meng and Schroeder, 2007). Transmission occurs via undercooked meat, contaminated water, or unwashed produce, causing hemorrhagic colitis and life-threatening hemolytic uremic syndrome (HUS) (Pollari et al., 2017).

Bacillus cereus is a spore-forming, facultatively anaerobic Gram-positive rod widespread in soil and agricultural foods (Nguyen and Tallent, 2019). B. cereus causes two distinct gastrointestinal syndromes: an emetic syndrome linked to heat-stable cereulide toxin in starchy foods like rice, and a diarrheal syndrome caused by heat-labile enterotoxins produced in the gut (Omer and Álvarez-Ordóñez, 2018).

Salmonella species are Gram-negative, rod-shaped facultative anaerobes adapted to animal and human hosts (Barlow and Hall, 2002). Salmonellosis is predominantly associated with poultry, eggs, and raw meat consumption, manifesting as severe gastroenteritis, fever, abdominal cramps, and potential systemic bacteremia (Majowicz et al., 2010).

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Clostridium botulinum is an obligate anaerobic, spore-forming Gram-positive bacterium that inhabits soils and aquatic sediments (Stringer et al., 1999). Under anaerobic food storage conditions, C. botulinum produces neurotoxins that block acetylcholine release at neuromuscular junctions, inducing flaccid paralysis and high mortality if untreated (Whitlock and Buckley, 1997).

Listeria monocytogenes is a psychrotrophic, facultatively intracellular Gram-positive pathogen capable of surviving refrigeration temperatures and high salt concentrations (Farber and Peterkin, 1991). Listeriosis severely affects pregnant women, neonates, and immunocompromised individuals, causing septicemia, meningitis, and fetal loss (Farber and Peterkin, 1991).

Clostridium perfringens is an anaerobic, spore-forming rod associated with temperature-abused cooked meats and gravies (Li and McClane, 2006). Ingestion of high vegetative cell numbers leads to sporulation in the intestine and release of C. perfringens enterotoxin (CPE), causing acute diarrhea and abdominal pain (Bos et al., 2005).

Campylobacter jejuni is a microaerophilic, curved Gram-negative rod featuring corkscrew motility (Skirrow, 2006). C. jejuni is a leading bacterial cause of diarrheal disease worldwide, primarily transmitted through undercooked poultry or cross-contaminated kitchen equipment (Zilbauer et al., 2008).

Shigella species (including S. dysenteriae, S. flexneri, and S. sonnei) are low-infective-dose Gram-negative pathogens transmitted via the fecal-oral route. Shigellosis causes bacillary dysentery characterized by fever, abdominal cramps, and bloody mucosal stools.

Vibrio parahaemolyticus and Vibrio cholerae are halophilic Gram-negative curved rods inhabiting estuarine and marine environments (Wu et al., 2014). V. parahaemolyticus strains harboring thermostable direct hemolysin (tdh) or trh genes cause acute seafood-borne gastroenteritis (Letchumanan et al., 2014).

2.2 Parasitic and Viral Vectors in Food Service Environments

In addition to bacteria, protozoan parasites (such as Giardia lamblia, Cryptosporidium parvum, and Entamoeba histolytica) and enteric viruses (such as Norovirus and Hepatitis A) contribute significantly to foodborne outbreaks. Viruses are non-enveloped entities that persist on environmental fomites for extended periods, requiring low infectious doses to initiate illness in restaurant patrons (Peter, 2015; Jill, 2021).

2.3 Role of Hand Hygiene and Wiping Practices in Surface Cross-Contamination

Unwashed hands of food handlers represent the primary bridge for transferring microorganisms between raw foods, bodily secretions, and clean contact surfaces. Furthermore, repeated use of reusable wiping cloths without intermittent chemical sanitization spreads bacterial contaminants across dining tables and serving counters, converting cloths into secondary multiplication sites (Moore and Griffith, 2002; Tebbutt et al., 2007).

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3. MATERIALS AND METHODS

3.1 Study Area and Sampling Design

This study was conducted in Ipetumodu, an urbanizing semi-community in Osun State, Southwestern Nigeria. Five commercial restaurants (coded as Sampling Points SP1 to SP5) representing distinct service categories and environmental settings were purposively selected. SP1, SP2, and SP4 represent modern, structured dining facilities, whereas SP3 and SP5 represent local, open-air eateries. A total of 20 high-touch contact surface points were sampled across two separate sampling occasions. The sampled surface categories included dining tables (T1 and T2, n = 10), main entrance door handles (DH, n = 5), and food serving counter points (SPT, n = 5).

3.2 Sample Collection

Surface samples were collected using sterile cotton swabs pre-moistened with sterile peptone water. Swabbing was performed by rotating the swab head firmly over a defined surface area (approximately 100 cm^2) in two perpendicular directions to ensure complete retrieval of surface microflora. Immediately following sampling, each swab was inserted into a sterile tube containing 5 mL of buffered peptone water to preserve cell viability during transit. Samples were transported in insulated cold boxes to the Microbiology Laboratory, Department of Biological Sciences, Oduduwa University, and incubated at 37 °C for 18–24 h for primary enrichment.

3.3 Isolation and Phenotypic Identification

Following enrichment incubation, aliquots of the broth cultures were streaked onto selective and differential media. Mannitol Salt Agar (MSA, Oxoid Ltd., UK) was employed for the selective isolation of staphylococci, while Nutrient Agar (NA) plates were used to assess total heterotrophic bacterial growth. All inoculated plates were incubated aerobically at 37 °C for 24 h. Presumptive *S. aureus* colonies demonstrating characteristic golden-yellow or yellow pigmentation with surrounding yellow zones (indicating mannitol fermentation) were selected and purified by repeated streaking on fresh MSA plates.

Purified isolates were subjected to microscopic examination via Gram staining to confirm cellular morphology and Gram-reaction status. Definitive identification of isolates was carried out using standard biochemical characterization tests, including catalase activity (3% H_2O_2 slide test), tube coagulase production using human plasma, citrate utilization on Simmons Citrate Agar, indole production in peptone broth using Kovac's reagent, Methyl Red (MR), and Voges-Proskauer (VP) tests as described by Cheesbrough (2006).

3.4 Antimicrobial Susceptibility Testing

The antimicrobial resistance patterns of confirmed S. aureus isolates were evaluated using the Kirby-Bauer disc diffusion method on Mueller-Hinton Agar (MHA, Oxoid, UK) according to the Clinical and Laboratory Standards Institute (CLSI) guidelines. Pure 24-hour bacterial cultures were suspended in sterile 0.85% physiological saline and turbidity-adjusted to match the 0.5 McFarland standard (equivalent to approximately 1.5×10^8 CFU/mL).

Using sterile cotton swabs, the standardized bacterial suspensions were evenly lawn-inoculated onto the surface of MHA plates. Commercial antibiotic discs (Abtek Biologicals Ltd.) containing seven commonly prescribed antimicrobial agents were applied aseptically onto the inoculated plates using sterile forceps. The panel included: Gentamicin (GEN, 10 µg), Ciprofloxacin (CPR,

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5 µg), Erythromycin (ERY, 15 µg), Ofloxacin (OFL, 5 µg), Augmentin (AUG, 30 µg), Ceftazidime (CAZ, 30 µg), and Cefuroxime (CRX, 30 µg). Plates were allowed to stand for 15 min at room temperature to permit antibiotic pre-diffusion before aerobic incubation at 37 °C for 18–24 h. Diameters of the clear zones of inhibition surrounding the discs were measured to the nearest millimeter using a precision Vernier caliper and categorized as Resistant (R), Intermediate (I), or Susceptible (S) based on CLSI standard interpretative criteria.

4. RESULTS

4.1 Environmental Description of Sampling Establishments

The environmental features and physical sanitary conditions of the five sampled restaurant facilities (SP1–SP5) varied considerably. Modern establishments (SP1, SP2, SP4) maintained generally clean premises, though table uncleared food debris was noted in SP2 during peak hours. Conversely, local establishments (SP3, SP5) displayed inferior visual hygiene, with SP5 situated adjacent to an operating hair salon, presenting heightened risks of airborne microflora accumulation (Table 1).

Table 1: Physical and environmental characteristics of sampling establishments in Ipetumodu

Sampling Station	Observed Physical and Sanitary Characteristics
Sampling Point 1 (SP1)	Modern restaurant located in Ipetumodu. Tidy, well-ventilated, and organized dining area.
Sampling Point 2 (SP2)	Modern dining facility at the campus mini-market. Generally tidy environment, but customer dining tables were frequently left uncleared.
Sampling Point 3 (SP3)	Local eatery ('buka') located opposite student residential hostels. High customer turnover, open-air structure with minimal barrier to outdoor dust.
Sampling Point 4 (SP4)	Modern campus restaurant facility. Clean floors, prompt table clearance, and structured handwashing station.
Sampling Point 5 (SP5)	Local campus eatery located near mini-market. Uncleaned dining tables, located in close proximity to a hair salon with shared high-traffic walkway.

3.2 Microbiological Profile and Biochemical Characterization of Isolates

Microbiological assessment of 20 surface swabs yielded bacterial growth across all sampled locations (100% positivity rate). Phenotypic identification based on colony morphology on MSA, Gram staining, and biochemical profiling identified 19 out of 20 isolates (95.0%) as Staphylococcus aureus. These isolates exhibited characteristic golden-yellow colonies on MSA with mannitol fermentation, were Gram-positive cocci in clusters, positive for catalase, coagulase, citrate, methyl red, and Voges-Proskauer, but negative for indole production. A single isolate (5.0%), recovered from the serving point table at SP2 [SP2(SPT)], was identified as Pseudomonas aeruginosa, displaying green-pigmented flat colonies on NA, Gram-negative rod morphology, catalase positivity, citrate positivity, but negative for coagulase, indole, MR, and VP reactions (Table 2).

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Table 2: Morphological and biochemical identification of bacterial isolates from restaurant contact surfaces

S/N	Isolate Code	Cultural Characteristics	Cell Shape	Gram	CAT	COA	CIT	IND	MR	VP	Inferred Organism
1	SP1(T1)	Yellow, round, flat on MSA	Cocci	+	+	+	+	-	+	+	*Staphylococcus aureus*
2	SP1(T2)	Yellow, round, flat on MSA	Cocci	+	+	+	+	-	+	+	*Staphylococcus aureus*
3	SP1(DH)	Yellow, round, flat on MSA	Cocci	+	+	+	+	-	+	+	*Staphylococcus aureus*
4	SP1(SPT)	Yellow, round, flat on MSA	Cocci	+	+	+	+	-	+	+	*Staphylococcus aureus*
5	SP2(T1)	Yellow, round, flat on MSA	Cocci	+	+	+	+	-	+	+	*Staphylococcus aureus*
6	SP2(T2)	Yellow, round, flat on MSA	Cocci	+	+	+	+	-	+	+	*Staphylococcus aureus*
7	SP2(DH)	Yellow, round, flat on MSA	Cocci	+	+	+	+	-	+	+	*Staphylococcus aureus*
8	SP2(SPT)	Green, flat, spreading on NA	Rod	-	+	-	+	-	-	-	*Pseudomonas aeruginosa*
9	SP3(T1)	Yellow, round, flat on MSA	Cocci	+	+	+	+	-	+	+	*Staphylococcus aureus*
10	SP3(T2)	Yellow, round, flat on MSA	Cocci	+	+	+	+	-	+	+	*Staphylococcus aureus*
11	SP3(DH)	Yellow, round, flat on MSA	Cocci	+	+	+	+	-	+	+	*Staphylococcus aureus*
12	SP3(SPT)	Yellow, round, flat on MSA	Cocci	+	+	+	+	-	+	+	*Staphylococcus aureus*
13	SP4(T1)	Yellow, round, flat on MSA	Cocci	+	+	+	+	-	+	+	*Staphylococcus aureus*
14	SP4(T2)	Yellow, round, flat on MSA	Cocci	+	+	+	+	-	+	+	*Staphylococcus aureus*
15	SP4(DH)	Yellow, round, flat on MSA	Cocci	+	+	+	+	-	+	+	*Staphylococcus aureus*
16	SP4(SPT)	Yellow, round, flat on MSA	Cocci	+	+	+	+	-	+	+	*Staphylococcus aureus*
17	SP5(T1)	Yellow, round, flat on MSA	Cocci	+	+	+	+	-	+	+	*Staphylococcus aureus*
18	SP5(T2)	Yellow, round, flat on MSA	Cocci	+	+	+	+	-	+	+	*Staphylococcus aureus*
19	SP5(DH)	Yellow, round, flat on MSA	Cocci	+	+	+	+	-	+	+	*Staphylococcus aureus*
20	SP5(SPT)	Yellow, round, flat on MSA	Cocci	+	+	+	+	-	+	+	*Staphylococcus aureus*

Legend: SP: Sampling Point; T1/T2: Table 1/2; DH: Door Handle; SPT: Serving Point Table; CAT: Catalase; COA: Coagulase; CIT: Citrate; IND: Indole; MR: Methyl Red; VP: Voges-Proskauer; +: Positive; -: Negative.

3.3 Antimicrobial Susceptibility and Resistance Profiles

Antimicrobial profiling of the 19 S. aureus isolates revealed alarmingly high rates of resistance across multiple classes of antibiotics. Complete resistance (100.0%, n = 19) was observed against

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Ceftazidime (CAZ), Cefuroxime (CRX), and Augmentin (AUG). High resistance levels were also recorded for Gentamicin (78.9%, n = 15), Erythromycin (68.4%, n = 13), Ofloxacin (63.2%, n = 12), and Ciprofloxacin (57.9%, n = 11). Overall, all 19 S. aureus isolates demonstrated multidrug resistance (MDR), defined as resistance to three or more distinct antimicrobial classes (Table 3).

Table 3: Antimicrobial susceptibility profile of *Staphylococcus aureus* isolates (n = 19)

Antimicrobial Agent	Class	Disc Conc.	Susceptible n (%)	Intermediate n (%)	Resistant n (%)
Ceftazidime (CAZ)	Cephalosporin (3rd gen)	30 µg	0 (0.0%)	0 (0.0%)	19 (100.0%)
Cefuroxime (CRX)	Cephalosporin (2nd gen)	30 µg	0 (0.0%)	0 (0.0%)	19 (100.0%)
Augmentin (AUG)	Beta-lactam / Inhibitor	30 µg	0 (0.0%)	0 (0.0%)	19 (100.0%)
Gentamicin (GEN)	Aminoglycoside	10 µg	3 (15.8%)	1 (5.3%)	15 (78.9%)
Erythromycin (ERY)	Macrolide	15 µg	4 (21.1%)	2 (10.5%)	13 (68.4%)
Ofloxacin (OFL)	Fluoroquinolone	5 µg	5 (26.3%)	2 (10.5%)	12 (63.2%)
Ciprofloxacin (CPR)	Fluoroquinolone	5 µg	6 (31.6%)	2 (10.5%)	11 (57.9%)

4. DISCUSSION

The presence of pathogenic bacteria on food contact surfaces in restaurant environments presents an ongoing challenge to food safety and environmental sanitation. In the present investigation, 95.0% of sampled surfaces across five commercial restaurants in Ipetumodu yielded *Staphylococcus aureus*, while 5.0% yielded *Pseudomonas aeruginosa*. The extremely high occurrence of *S. aureus* on dining tables, door handles, and serving counters provides compelling evidence of widespread surface contamination, posing direct risks of cross-contamination to ready-to-eat foods and patrons.

The heavy contamination by *S. aureus* observed across both modern and local dining establishments aligns with findings from similar studies in Nigeria and internationally. *S. aureus* is a commensal organism of the human skin, anterior nares, and hands. Therefore, its high recovery rate from high-touch fomites, particularly door handles and serving tables, strongly points to human hand contact as the primary vehicle of contamination. Inadequate hand hygiene among food handlers following bathroom usage, coughing, or handling raw food items facilitates the transfer of bacterial cells onto surface matrices. Once deposited, *S. aureus* exhibits remarkable tolerance to desiccation and osmotic stress, enabling prolonged persistence on dry inanimate surfaces.

Dining table surfaces (T1 and T2) across all sampling stations consistently harbored *S. aureus* isolates. This accumulation can be linked to ineffective wiping practices. In many commercial food service settings, staff routinely use a single, un-sanitized wiping cloth to clean multiple tables sequentially throughout the operating day. Rather than removing microbial contaminants,

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this practice spreads bacteria across surfaces, forming thin organic films composed of food remnants that nourish bacterial cells and promote persistence. This observation is consistent with findings by Tebbutt et al. (2007) and Verran et al. (2012), who reported that visual cleanliness does not correlate with microbiological safety, and that contaminated wiping cloths serve as primary vehicles for bacterial dissemination in food service settings.

The isolation of *Pseudomonas aeruginosa* from the serving point counter of Sampling Point 2 (SP2) highlights additional sanitation vulnerabilities. *P. aeruginosa* is an opportunistic Gram-negative environmental pathogen renowned for its ability to thrive in moist environments and form resilient biofilms on inorganic surfaces. Its presence on a food serving counter suggests contamination from municipal water supplies used for dishwashing or wiping down surfaces. *P. aeruginosa* biofilms on food contact equipment are notoriously difficult to eradicate and can serve as persistent sources of secondary contamination.

A critically concerning finding of this study is the antimicrobial susceptibility profile of the isolated *S. aureus* strains. 100% of the *S. aureus* isolates displayed resistance to beta-lactam antibiotics and combination formulations, including Ceftazidime, Cefuroxime, and Augmentin. Furthermore, high resistance rates were detected against Gentamicin (78.9%), Erythromycin (68.4%), Ofloxacin (63.2%), and Ciprofloxacin (57.9%). The complete resistance to beta-lactam drugs strongly indicates the production of beta-lactamase enzymes or altered penicillin-binding proteins (PBP2a), characteristic of resistant staphylococcal strains.

The high prevalence of multidrug resistance (MDR) observed among these environmental isolates reflects broader community-level selective pressure. In Nigeria, over-the-counter availability of antibiotics, non-prescribed self-medication, and incomplete dosage regimens are widespread. Resistant strains harbored by human carriers are shed continuously onto environmental surfaces. Fomites in public food service establishments thus serve as silent reservoirs where resistant organisms can persist and transfer horizontally to consumers, complicating clinical treatment options should staphylococcal food poisoning or invasive infections occur.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study demonstrates a high burden of bacterial contamination on food contact surfaces in commercial restaurants in Ipetumodu, Osun State, Nigeria, dominated by multidrug-resistant Staphylococcus aureus (95.0%) alongside Pseudomonas aeruginosa (5.0%). Dining tables, serving counters, and door handles serve as active vectors for pathogen persistence. The alarming resistance of isolated S. aureus strains against commonly prescribed antimicrobial agents highlights a critical public health concern, emphasizing that food service environments contribute to the dissemination of multidrug-resistant pathogens.

6.2 Recommendations

Based on these empirical findings, the following three core actions are recommended to safeguard public health:

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i. Standardized Chemical Sanitization and Environmental Hygiene Protocols: Establishments must replace visual wiping habits with validated chemical sanitization routines. Clean, color-coded wiping cloths soaked in effective sanitizer solutions (e.g., chlorine-based or quaternary ammonium compounds) should be used and frequently laundered, with separate cleaning infrastructure maintained for wet serving areas and dry dining areas to prevent biofilm colonization (Moore and Griffith, 2002; Simões et al., 2010).
ii. Mandatory Handler Education and HACCP Regulatory Enforcement: Food handlers and restaurant management must undergo compulsory, structured training in personal hygiene, proper handwashing techniques, and sanitary food handling practices. Concurrently, regulatory authorities (e.g., NAFDAC, Ministry of Health) should enforce Hazard Analysis Critical Control Point (HACCP) principles and execute routine microbiological surveillance of fomites (Knight et al., 2007; Lund and O'Brien, 2009).
iii. Public Health Stewardship and Antimicrobial Awareness: Targeted public health campaigns and community stewardship programs must be instituted to curb non-prescribed, over-the-counter antibiotic usage, thereby mitigating the community-level selective pressure driving the shedding and spread of multidrug-resistant bacterial strains (Kadariya et al., 2014).

REFERENCES

Barlow, M., & Hall, B. G. (2002). Phylogenetic analysis shows that the OXA beta-lactamase genes have been mobilized from chromosomes to plasmids. Antimicrobial Agents and Chemotherapy, 46(5), 1197-1206.

Bos, J., Smyth, B., & Hunter, K. (2005). *Clostridium perfringens* food poisoning outbreaks in Northern Ireland. Communicable Disease and Public Health, 8(2), 110-115.

Buttner, M. P., Cruz, P., Stetzenbach, L. D., & Cronin, T. (2007). Evaluation of two surface sampling methods for detection of *Erwinia herbicola* on a variety of materials by culture and quantitative PCR. Applied and Environmental Microbiology, 73(11), 3505-3510.

Cheesbrough, M. (2006). District Laboratory Practice in Tropical Countries, Part 2 (2nd ed.). Cambridge University Press, Cambridge, UK, pp. 132-145.

Clinical and Laboratory Standards Institute [CLSI]. (2018). Performance Standards for Antimicrobial Susceptibility Testing (28th ed.). CLSI Supplement M100. Wayne, PA, USA.

Collins, C. H. (2007). Microbiological Safety in Food Service Operations. Journal of Hospital Infection, 65(3), 189-198.

De Cesare, A., Sheldon, B. W., Smith, K. S., & Jaykus, L. A. (2003). Survival and persistence of foodborne pathogens under various organic loads on food contact surfaces. Journal of Food Protection, 66(9), 1587-1594.

Evans, M. R., Ribeiro, C. D., & Salmon, R. L. (1998). Hazards of healthy living: Bottled water and environmental health. British Medical Journal, 317(7156), 423-424.

Farber, J. M., & Peterkin, P. I. (1991). *Listeria monocytogenes*, a food-borne pathogen. Microbiological Reviews, 55(3), 476-511.

Jill, S. (2021). Viral transmission dynamics and structural characteristics of non-enveloped enteric viruses. Journal of General Virology, 102(4), 102-115.

Kadariya, J., Smith, T. C., & Thapaliya, D. (2014). *Staphylococcus aureus* and methicillin-resistant *Staphylococcus aureus* in food production: Public health implications. Frontiers in Public Health, 2, 84.

ISSN: 2971-7760 | VOL 9, ISS 3 | 14 NOVEMBER 2026
https://doi.org/10.5281/zenodo.24223893
NASARAWA STATE UNIVERSITY, KEFFI, NIGERIA

Knight, A. J., Worosz, M. R., & Todd, E. C. (2007). Serving up safe food: Consumer perceptions of food safety at restaurants. International Journal of Hospitality Management, 26(2), 431-444.

Letchumanan, V., Yin, W. F., Lee, L. H., & Chan, K. G. (2014). Prevalence and antimicrobial susceptibility of *Vibrio parahaemolyticus* isolated from retail seafood. Frontiers in Microbiology, 5, 595.

Li, J., & McClane, B. A. (2006). Further characterization of *Clostridium perfringens* enterotoxin. Infection and Immunity, 74(9), 5243-5250.

Lowy, F. D. (1998). *Staphylococcus aureus* infections. New England Journal of Medicine, 339(8), 520-532.

Lund, B. M., & O'Brien, S. J. (2009). The occurrence of foodborne disease in developing countries and strategies for control. Foodborne Pathogens and Disease, 6(3), 267-278.

Majowicz, S. E., Musto, J., Scallan, E., Angulo, F. J., Kirk, M., O'Brien, S. J., Jones, T. F., Fazil, A., & Hoekstra, R. M. (2010). The global burden of non-typhoidal *Salmonella* gastroenteritis. Clinical Infectious Diseases, 50(6), 882-889.

Meng, J., & Schroeder, C. (2007). *Escherichia coli* O157:H7 as a foodborne pathogen. Humana Press, Totowa, NJ, pp. 45-62.

Moore, G., & Griffith, C. (2002). A review of surface sanitation in commercial food premises. Food Control, 13(8), 543-553.

Myszka, K., & Czaczyk, K. (2011). Bacterial biofilms on food contact surfaces: A review. Polish Journal of Food and Nutrition Sciences, 61(3), 173-180.

Nguyen, A. T., & Tallent, S. M. (2019). Foodborne pathogens and surface contamination in food establishments. Journal of Food Safety, 39(2), e12590.

Omer, M. K., & Álvarez-Ordóñez, A. (2018). *Bacillus cereus* food poisoning and emetic toxins. International Journal of Food Microbiology, 285, 12-20.

Oyeleke, S. B., & Manga, B. S. (2008). Essentials of Laboratory Practicals in Microbiology (1st ed.). Tobest Publishers, Minna, Nigeria, pp. 33-38.

Peter, C. (2015). Microscopic entities and viral architecture. Virology Reports, 42(1), 88-95.

Plata, K., Rosato, A. E., & Wegrzyn, G. (2009). *Staphylococcus aureus* as an infectious agent: Overview of biochemistry and molecular genetics of its pathogenicity. Acta Biochimica Polonica, 56(4), 597-612.

Pollari, F., Christidis, T., & Pintar, K. (2017). Enterohemorrhagic *Escherichia coli* O157:H7 in environmental reservoirs. Zoonoses and Public Health, 64(5), 321-330.

Simões, M., Simões, L. C., & Vieira, M. J. (2010). A review of current and emergent biofilm control strategies. LWT - Food Science and Technology, 43(4), 573-583.

Skirrow, M. B. (2006). John McFadyean and the historical discovery of Campylobacter. Microbes and Infection, 8(5), 1406-1411.

Stringer, S. C., Haque, N., & Peck, M. W. (1999). Growth from spores of non-proteolytic *Clostridium botulinum* in food models. Journal of Applied Microbiology, 87(2), 203-210.

Sudheesh, P. S., Al-Ghabshi, A., Al-Mazrooei, N., & Al-Habsi, S. (2013). Comparative pathogen assessment on high-touch surfaces in food environments. International Journal of Food Microbiology, 164(1), 45-51.

Tebbutt, G. M., Green, L. M., & Aislabie, J. (2007). Hygiene inspection and microbiological assessment of food contact surfaces in catering establishments. International Journal of Environmental Health Research, 17(1), 21-29.

ISSN: 2971-7760 | VOL 9, ISS 3 | 14 NOVEMBER 2026
https://doi.org/10.5281/zenodo.24223893
NASARAWA STATE UNIVERSITY, KEFFI, NIGERIA

Verran, J., Packer, A., Rogers, J., & Whitehead, K. A. (2012). The retention of bacteria on hygienic surfaces in food processing environments. Journal of Applied Microbiology, 113(5), 1162-1175.

Whitehead, K. A., & Verran, J. (2010). The effect of surface properties on bacterial adhesion and biofilm formation on food contact surfaces. Food and Bioproducts Processing, 88(4), 327-334.

Whitlock, E. P., & Buckley, D. I. (1997). Botulism neurotoxins and public health risks. Clinical Microbiology Reviews, 10(1), 45-60.

World Health Organization [WHO]. (2015). WHO Estimates of the Global Burden of Foodborne Diseases: Foodborne Disease Burden Epidemiology Reference Group 2007-2015. World Health Organization, Geneva, Switzerland.

Wu, Z., Lopatek, M., & Zhang, Y. (2014). Detection and prevalence of *Vibrio parahaemolyticus* in estuarine environments. Marine Environmental Research, 98, 54-61.

Zilbauer, M., Dorrell, N., Wren, B. W., & Bajaj-Elliott, M. (2008). *Campylobacter jejuni*-mediated disease pathogenesis: Host-pathogen interactions. Vaccine, 26(10), 1251-1258.