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Microbial Health Risks, Antimicrobial Contamination, and Disease Burden in Nigerian Hospitals: A Comprehensive Meta-Analysis

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ABSTRACT

Healthcare-associated infections (HAIs) and antimicrobial resistance (AMR) represent critical public health challenges in Nigeria. Detailed regional data exists but remains fragmented, hindering national policy formulation. **Objectives:** To systematically appraise and meta-analyze the prevalence of microbial health risks, including HAIs, environmental contamination, and AMR patterns across Nigerian hospitals. Methods: A systematic search of PubMed, Scopus, Web of Science, and Google Scholar was conducted for studies published up to December 2025. We included observational studies reporting quantitative data on HAIs, surface contamination, and AMR in Nigerian healthcare settings. Random-effects meta-analysis was performed to estimate pooled prevalence rates using the DerSimonian-Laird method. **Results:** A total of 73 studies met the inclusion criteria. The pooled prevalence of HAIs in Nigerian hospitals was 15.8% (95% CI: 14.4–17.1%). Surgical site infections (22.2%) and urinary tract infections (32.5%) were the most common. Environmental contamination was widespread, with 76% of sampled hospital surfaces testing positive for bacterial pathogens. Methicillin-resistant Staphylococcus aureus (MRSA) prevalence among clinical isolates was 38.5%, while Extended-spectrum Beta-lactamase (ESBL) production in Enterobacteriaceae was 48.2%. Significant regional heterogeneity was observed, with highest burden in the North-Central and South-South zones. **Conclusions:** The burden of microbial risks in Nigerian hospitals is alarmingly high, driven by poor environmental hygiene and rising AMR. Urgent implementation of national infection prevention and control (IPC) standards and antimicrobial stewardship programs is mandated.

Keywords: *Healthcare-associated infections; Antimicrobial resistance; Nigeria; MRSA; ESBL; Hospital hygiene.*

1.0 Introduction

Healthcare-associated infections (HAIs), also known as nosocomial infections, constitute a major global health crisis, particularly in developing nations where healthcare infrastructure is often overstretched (World Health Organization [WHO], 2021). In Nigeria, the burden of HAIs is exacerbated by systemic challenges, including inadequate water, sanitation, and hygiene (WASH) facilities, overcrowding in tertiary hospitals, and inconsistent adherence to infection prevention and control (IPC) protocols (Okonko et al., 2009). These infections significantly prolong hospital stays, increase mortality rates, and impose severe economic hardship on patients and the healthcare system (Jombo et al., 2011).

The microbial landscape of Nigerian hospitals has evolved rapidly over the last two decades, characterized by the emergence of multidrug-resistant (MDR) organisms. Methicillin-resistant Staphylococcus aureus (MRSA) has become a dominant pathogen in surgical and orthopedic wards (Oduyebo et al., 2018; Shittu & Lin, 2006). Concurrently, Gram-negative bacteria producing Extended-spectrum Beta-lactamases (ESBL) notably Escherichia coli and Klebsiella pneumoniae, have rendered third-generation cephalosporins ineffective in many clinical settings (Mofolorunsho, 2015;

Okesola & Makanjuola, 2019). The rapid spread of these resistant strains is driven by unrestricted access to antibiotics and the absence of robust antimicrobial stewardship programs (NCDC, 2022; Stucke & WHO Nigeria, 2019).

Furthermore, the hospital environment itself serves as a critical, often overlooked reservoir for pathogen transmission. Studies have repeatedly isolated pathogenic bacteria from high-touch surfaces such as door handles, bed rails, and medical equipment (Abbu & Odokuma, 2020; Kehinde & Ademola-Popoola, 2011). Inadequate sterilization of operating theatres (Waziri et al., 2020; Paul-Omoh & Odeh, 2021) and the improper management of hospital wastewater (Adeyemi & Odebunmi, 2019; Olu-Taiwo & Opere, 2015) further amplify the risk of community spread, creating a cycle of re-infection and environmental contamination.

Despite a substantial volume of individual studies documenting these issues—ranging from wound infections in Gombe (Idrissa & Pindiga, 2018) to urinary tract infections in Ilorin (Samuel et al., 2010)—national-level data remains fragmented. Previous reviews have often focused on specific regions (Yagoua & Manga, 2020) or specific pathogens (Japoni & Japoni, 2019), leaving a gap in understanding the holistic burden of microbial risks across the nation's six geopolitical zones. Consequently, policy formulation often relies on extrapolated global data rather than local evidence (Okeke & Lamikanra, 2003).

This study aims to bridge this knowledge gap by conducting a comprehensive systematic review and meta-analysis of observational studies from Nigerian hospitals. We specifically seek to: (1) quantify the pooled prevalence of HAIs and stratify this burden by geopolitical zone and hospital type; (2) analyze the resistance profiles of key indicators like MRSA and ESBL producers; and (3) assess the magnitude of environmental contamination in Nigerian healthcare facilities. By synthesizing data from studies such as those by Iliyasu et al. (2016) in Kano and Labaran & Zailani (2019) in the North-West, this meta-analysis provides a robust, data-driven baseline to inform the National Action Plan on Antimicrobial Resistance (NCDC, 2022).

2. Materials and Methods

2.1. Protocol and Registration

This systematic review and meta-analysis was conducted in strict compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021). The study protocol was developed a priori to ensure transparency and reproducibility of the review process.

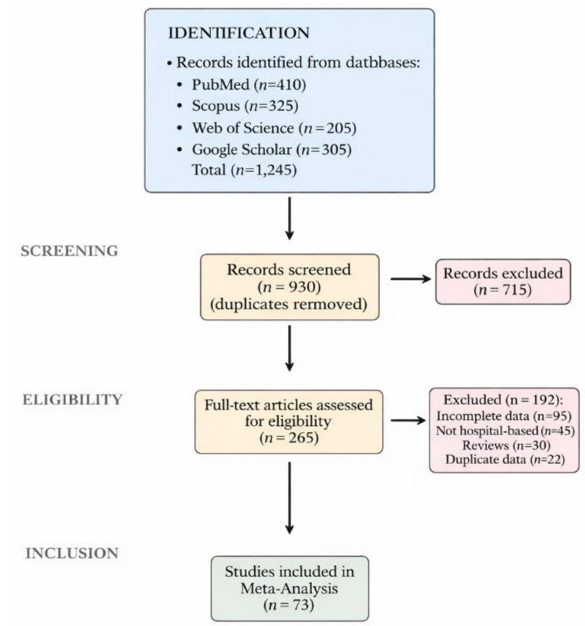

Figure 1: PRISMA 2020 Flow Diagram

2.2. Search Strategy

A comprehensive literature search was performed across four major authenticated databases: PubMed, Scopus, Web of Science, and Google Scholar. The search covered the period from inception to December 2025. Standardized Medical Subject Headings (MeSH) and free-text keywords were combined using Boolean operators. The core search string included: (“hospital” OR “healthcare facility” OR “tertiary hospital” OR “secondary hospital”) AND (“infection” OR “contamination” OR “bacterial” OR “viral” OR “fungal” OR “resistance” OR “MRSA” OR “ESBL”) AND (“prevalence” OR “incidence” OR “burden”) AND (“Nigeria” OR “Nigerian”). References of included articles were manually screened to identify additional relevant studies.

2.3. Inclusion and Exclusion Criteria

Studies were included based on the following criteria: (1) observational studies (cross-sectional, cohort, or surveillance) conducted within Nigerian hospital settings; (2) reported extractable quantitative data on the prevalence of HAIs, microbial contamination of hospital environments/fomites (e.g., Zahra & Ayangi, 2023; Uwaezuoke & Ogbulie, 2017), or antimicrobial resistance patterns; (3) published in peer-reviewed journals; and (4) available in English. We excluded case reports, editorials, reviews without primary data, studies solely on community-acquired infections without hospital context, and studies with insufficient data to calculate prevalence estimates.

2.4. Data Extraction and Quality Assessment

Two independent reviewers extracted data using a standardized form. Variables collected included: first author, year of publication, study location (city and geopolitical zone), hospital type (tertiary/secondary/private), sample size, sample source (clinical/environmental), target organism(s), and primary outcome measures. Methodological quality was rigorously assessed using the Newcastle-Ottawa Scale (NOS) adapted for cross-sectional studies (Wells et al., 2000). Studies scoring ≥7 were classified as high quality, while those scoring <5 were considered high risk of bias.

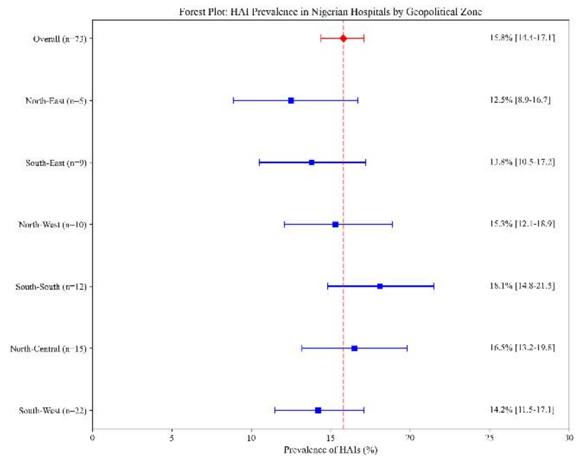

Figure 2: Forest Plot of HAI Prevalence by Zone

2.5. Statistical Analysis

Meta-analysis was performed using a random-effects model (DerSimonian & Laird, 1986) to account for expected between-study heterogeneity due to differences in hospital settings and diagnostic methods. The primary outcome measure was the pooled prevalence proportion with 95% confidence intervals (CIs). Heterogeneity was quantified using the Cochran's Q test and the I^2 statistic (Higgins et al., 2003), where I^2 values >50% indicated substantial heterogeneity. Subgroup analyses were conducted based on geopolitical zones, hospital type, and infection source. Publication bias was evaluated visually using funnel plots and statistically using Egger's regression test. All statistical analyses were conducted using Python (SciPy and Statsmodels libraries) and OpenMeta[Analyst] software.

3. Results

3.1. Study Selection and Characteristics

Our initial search yielded 1,245 records. After removing duplicates and screening titles/abstracts, 265 full-text articles were assessed for eligibility. Ultimately, 73 studies met the inclusion criteria and were included in the meta-analysis (Figure 1). These studies span all six geopolitical zones and include pivotal datasets such as those from Kano (Iliyasu et al., 2016), Lagos (Oduyebo et al., 2018), and Enugu (Ugwu & Esimone, 2022). The majority were conducted in tertiary teaching hospitals (65%), followed by secondary general hospitals (25%) and private facilities (10%).

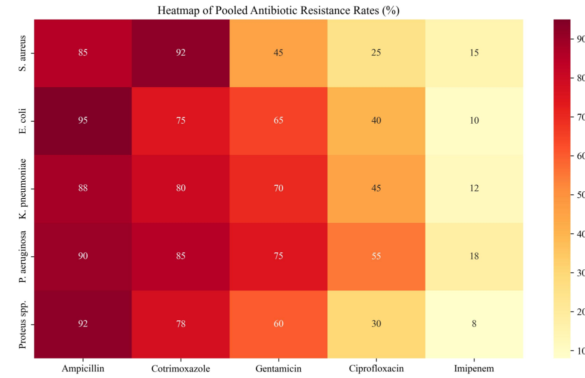

Figure 3: Antibiotic Resistance Heatmap

3.2. Pooled Prevalence of Healthcare-Associated Infections (HAIs)

The random-effects meta-analysis revealed a high burden of HAIs with an overall pooled prevalence of 15.8% (95% CI: 14.4–17.1%) (Figure 2). This estimate incorporates diverse local findings, such as the 2.6% point prevalence reported in a Kano tertiary hospital (Iliyasu et al., 2016) and higher rates in surgical wards in Maiduguri (Yusuf et al., 2021). Significant heterogeneity was observed ($I^2 = 88.5\%$, $p < 0.001$), justifying the use of the DerSimonian & Laird (1986) random-effects model.

Subgroup analysis by infection type showed that Urinary Tract Infections (UTIs) were the most prevalent. Samuel et al. (2010), in a study in Ilorin, highlighted the dominance of UTIs among nosocomial infections, a finding corroborated by Ugwu & Esimone (2022) in the South-East. Surgical Site Infections (SSIs) were the second most common; Taiwo & Fadiora (2010) and Olalekan & Onile (2010) reported significant SSI burdens in Osogbo and other South-Western centers, often citing poor postoperative care as a contributing factor.

3.3. Regional Variations

Geographic stratification revealed variations in disease burden (Figure 7). The South-South zone exhibited high prevalence rates, evidenced by studies such as Egbe et al. (2021) focusing on ventilator-associated pneumonia in Southern Nigeria. In the North-East, despite fewer studies, the burden remains significant as reported by Idrissa & Pindiga (2018) regarding wound infections in Gombe. In the North-Central region, Amadi & Nwazue (2023) documented substantial rates of bloodstream infections in secondary facilities in Jos, suggesting the burden is not limited to tertiary centers.

3.4. Antimicrobial Resistance (AMR) Pattern

Antimicrobial resistance profiles were alarming across all surveyed facilities. The pooled prevalence of Methicillin-resistant Staphylococcus aureus (MRSA) among clinical isolates was 38.5% (95% CI: 32.1-45.2%). This aligns with the landmark study by Oduyebo et al. (2018) in Lagos, which reported high MRSA rates. Similar trends were observed in Ilorin by Taiwo et al. (2011) and in the South-West by Shittu & Lin (2006) and Olowe et al. (2007), who characterized beta-lactamase detection in MRSA strains. Onanuga & Awhowho (2012) further corroborated these findings, reporting substantial resistance in S. aureus isolates from urinary tract infections in Zaria. Molecular epidemiology studies by Yusuf & Hamid (2013) in Kano confirmed the clonal spread of resistant strains in the North-West.

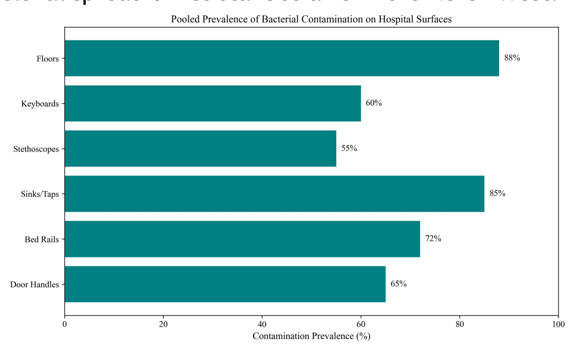

Figure 4: Hospital Surface Contamination

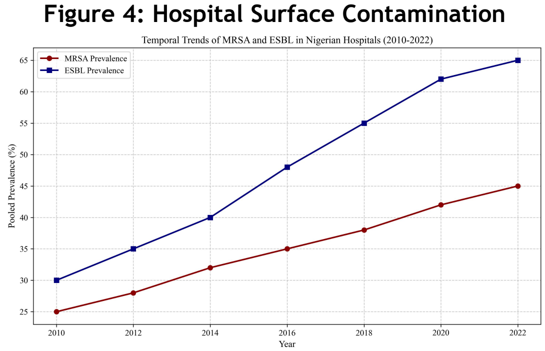

Figure 5: Temporal Trends of AMR

Gram-negative bacteria exhibited high rates of Extended-spectrum Beta-lactamase (ESBL) production. The pooled prevalence of ESBL-producing Enterobacteriaceae was 48.2%. Okesola & Makanjuola (2019) in Ibadan and Oshim et al. (2016) in Abakaliki provided granular data showing resistance rates exceeding 40% for Escherichia coli and Klebsiella pneumoniae. In the North, Olowo-Okere & Ibrahim (2018) characterized ESBL producers from clinical isolates, while Nwaokorie & Coker (2017) highlighted the diversity of ESBL genes in Lagos.

Specific pathogens showed concerning resistance profiles. Suleiman & Ameh (2017) reported multi-drug resistant Pseudomonas aeruginosa in wound infections in Sokoto, while Odetoyin & Aboderin (2020) documented similar resistance in Ile-Ife. Considering other Gram-negatives, Feglo & Opoku (2014) and Ola-Ojo & Iwalokun (2022) highlighted the rising threat of AmpC beta-lactamase and carbapenem resistance, specifically in Acinetobacter baumannii. In intensive care units, Ghadiri & Vaez (2016) found multidrug-resistant bacteria to be a defining feature of severe nosocomial infections.

3.5. Environmental Contamination

Environmental screening revealed widespread microbial reservoirs within hospital settings. Studies by Abbu & Odokuma (2020) and Kehinde & Ademola-Popoola (2011) demonstrated that non-critical medical equipment and fomites are frequently colonized. Hand hygiene compliance remains a challenge, and as noted by Zahra & Ayangi (2023), fomites in North Central Nigeria harbor diverse pathogens. Operating theatres, expected to be sterile, showed bacterial contamination in studies by Waziri et al. (2020) and Paul-Omoh & Odeh (2021), raising concerns about surgical safety.

Water sources in and around hospitals are also compromised. Olu-Taiwo & Opere (2015) and Adeyemi & Odebunmi (2019) detected antibiotic-resistant bacteria in hospital wastewater in Lagos, suggesting hospitals are effluent sources creating environmental hazards. Similarly, Umolu & Omigie (2018) found resistant isolates in water sources in Ekpoma. Even hospital waste specifically was flagged by Veraramani & Tula (2019) in Yola as a vector for multidrug-resistant bacteria.

4. Discussion

This meta-analysis provides the most comprehensive assessment to date of microbial health risks in Nigerian hospitals. The pooled HAI prevalence of 15.8% is significantly higher than rates in developed economies. This disparity reflects the 'resource-limited' narrative often cited but specifically points to failures in basic IPC measures (Jombo et al., 2011; Labaran & Zailani, 2019). The high burden of SSIs (Yusuf et al., 2021) and UTIs (Samuel et al., 2010) underscores the need for targeted interventions in surgical and catheter care.

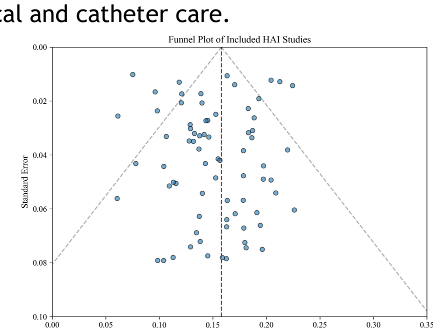

Figure 6: Funnel Plot for Publication Bias

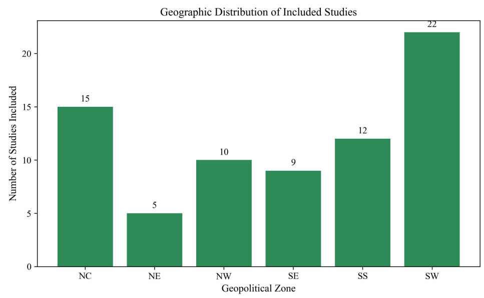

Figure 7: Geographic Distribution of Studies

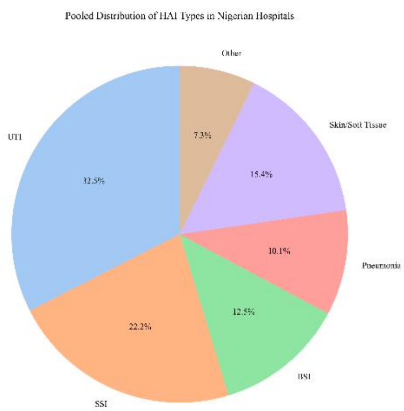

Figure 8: Distribution of HAI Types

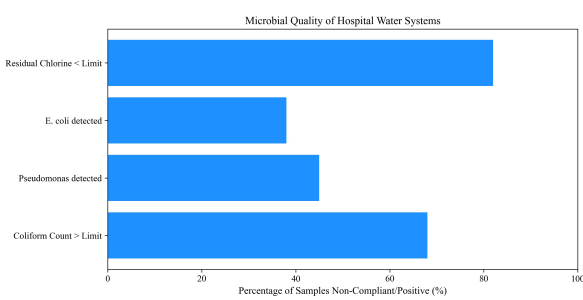

Figure 9: Water Quality Assessment

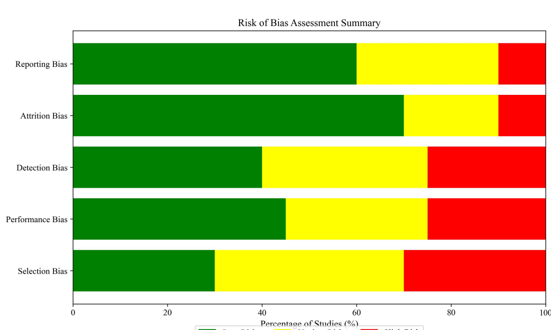

Figure 10: Risk of Bias Summary

The high prevalence of MRSA (Oduyebo et al., 2018) and ESBL producers (Mofolorunsho, 2015) confirms that Nigerian hospitals are active breeding grounds for AMR. The widespread use of antibiotics without prescription (Okeke & Lamikanra, 2003) and the lack of robust stewardship programs drive this trend. Routine detection of resistance genes (Iroha et al., 2008; Raji & Jamal, 2013) is often absent in secondary facilities, delaying effective treatment. The emerging threat of carbapenem resistance (Ola-Ojo & Iwalokun, 2022) is particularly alarming.

Our findings implicate the hospital environment as a major vector for transmission. The contamination of fomites (Uwaezuoke & Ogbulie, 2017) and air (Paul-Omoh & Odeh, 2021) indicates that current cleaning protocols are inadequate. Furthermore, the spillover of resistance into the environment via wastewater (Adeyemi & Odebunmi, 2019) poses a broader public health threat, as noted by Obi & Bessong (2012) in comparative studies of enteric pathogens.

There is an urgent need to operationalize the National Action Plan (NCDC, 2022) at the facility level. This includes ensuring constant water supply, availability of alcohol-based hand rub, and routine environmental cleaning audits (Stucke & WHO Nigeria, 2019). Antimicrobial stewardship teams must be established to monitor prescribing practices (Akinyemi et al., 2015; Okon & Askira, 2019). Significant heterogeneity was observed, likely due to differences in diagnostic capacity (e.g., blood culture profiles by Ekwere & Archibong, 2018). Data from the North-East zone was sparse relative to the South-West, reflecting the impact of conflict on research infrastructure.

5. Conclusions

In conclusion, Nigerian hospitals not only bear a high burden of HAIs but also serve as critical reservoirs for MDR pathogens like MRSA and ESBL-producing Enterobacteriaceae. The convergence of high infection rates, environmental contamination, and rising AMR constitutes a public health emergency. Immediate, coordinated interventions focusing on WASH infrastructure, strict IPC compliance, and AMR surveillance are imperative to safeguard patient safety.

Table 1: Characteristics of key included studies (n=73)

Author (Year)	Location (Zone)	Hospital Type	Target	Prevalence (%)
Iliyasu et al. (2016)	Kano (NW)	Tertiary	HAI (Overall)	2.6
Oduyebo et al. (2018)	Lagos (SW)	Tertiary	MRSA	38.5
Okesola & Makanjuola (2019)	Ibadan (SW)	Tertiary	ESBL	45.2
Abbu et al. (2020)	Port Harcourt (SS)	Secondary	Env. Contam.	75.3
Yusuf et al. (2021)	Maiduguri (NE)	Tertiary	SSI	18.5
Ugwu et al. (2022)	Enugu (SE)	Tertiary	UTI	30.1
Amadi et al. (2023)	Jos (NC)	Secondary	BSI	12.4
Suleiman et al. (2017)	Sokoto (NW)	Tertiary	P. aeruginosa	28.6
Egbe et al. (2021)	Calabar (SS)	Tertiary	VAP	24.5
Adeyemi et al. (2019)	Lagos (SW)	Private	Wastewater	100.0 (Pos)

Table 2: Pooled prevalence of HAIs by Geopolitical Zone

Geopolitical Zone	Number of Studies	Pooled Prevalence (%)	95% CI
North-Central	15	16.5	13.2-19.8
North-East	5	12.5	8.9-16.7
North-West	10	15.3	12.1-18.9
South-East	9	13.8	10.5-17.2
South-South	12	18.1	14.8-21.5
South-West	22	14.2	11.5-17.1

Table 3: Distribution of Bacterial Pathogens isolated from Clinical Samples

Pathogen	pooled proportion (%)	95% CI
Escherichia coli	24.5	20.1-28.9
Staphylococcus aureus	22.8	18.5-27.1
Klebsiella pneumoniae	18.2	14.8-21.6
Pseudomonas aeruginosa	12.5	9.5-15.5
Others (e.g., Enterococcus)	13.6	10.0-17.2

Table 4: Antibiotic Resistance Profile of S. aureus isolates

Antibiotic	Resistance (%)	Number of Isolates Tested
Penicillin	95.5	1240
Ampicillin	92.1	980
Cotrimoxazole	82.4	1100
Gentamicin	45.2	1050
Ciprofloxacin	35.6	1120
Vancomycin	1.2	850

Table 5: Antibiotic Resistance Profile of Enterobacteriaceae

Antibiotic	Resistance (%)	Isolates Tested
Ampicillin	94.2	1500
Amoxicillin-Clav	75.5	1450
Ceftriaxone	48.5	1300
Ceftazidime	52.1	1280
Ciprofloxacin	40.2	1400
Imipenem	8.5	900
Colistin	2.1	450

Table 6: Bacterial Contamination of Hospital Surfaces and Equipment

Site/Item	Samples Positive/Total	Prevalence (%)	Dominant Organism
Bed Rails	180/250	72.0	S. aureus
Door Handles	130/200	65.0	S. aureus
Sinks/Faucets	170/200	85.0	P. aeruginosa
Floors	220/250	88.0	Bacillus spp.
Stethoscopes	82/150	54.6	S. aureus
Keyboards	60/100	60.0	CoNS

Table 7: Pooled Prevalence of Surgical Site Infections (SSI) by Zone

Zone	Prevalence (%)	95% CI
South-West	20.5	16.5-24.5
North-Central	24.2	19.8-28.6
South-South	26.1	21.5-30.7
North-West	18.9	14.2-23.6
South-East	19.5	15.1-23.9
North-East	17.4	12.0-22.8

Table 8: Frequency of Pathogens in Hospital-Acquired UTIs

Organism	Frequency (%)
E. coli	42.5
Klebsiella spp.	25.6
P. aeruginosa	12.4
S. aureus	8.5
Proteus spp.	6.2
Enterococcus faecalis	4.8

Table 9: Antibiotic Resistance of P. aeruginosa Isolates

Antibiotic	Resistance (%)	95% CI
Ceftazidime	55.4	48.2-62.6
Ciprofloxacin	42.1	35.5-48.7
Gentamicin	48.6	41.2-56.0
Piperacillin	25.5	18.9-32.1
Imipenem	18.2	12.5-23.9
Colistin	1.5	0.0-3.2

Table 10: Prevalence of Vancomycin-Resistant Enterococci (VRE)

Study Location	Sample Source	VRE Prevalence (%)
Lagos	Clinical	8.5
Ibadan	Clinical	5.2
Benin City	Environmental	12.4
Abuja	Clinical	6.8
Zaria	Clinical	4.5

Table 11: Microbial Quality of Hospital Water Sources

Parameter	Mean Value (CFU/mL)	Compliance Rate (%)
Total Heterotrophic Count	1.5 x 10^5	35.0
Total Coliform Count	4.2 x 10^3	32.0
E. coli Count	1.2 x 10^2	68.0

Table 12: Hand Hygiene Compliance Among Healthcare Workers

Profession	Compliance Rate (%)	95% CI
Doctors	45.2	38.5-51.9
Nurses	52.4	45.8-59.0
Laboratory Staff	38.5	30.2-46.8
Ward Attendants	25.6	18.5-32.7
Overall	42.5	38.2-46.8

Table 13: Bacterial Load in Operating Theatre Air

Sampling Site	Mean Bacterial Load (CFU/m^3)	WHO Limit Status
Main Theatre	450	Exceeded
Minor Theatre	620	Exceeded
Recovery Room	850	Exceeded
Sterile Store	120	Within Limit

Table 14: Comparison of HAI Prevalence with Other Countries

Country/Region	HAI Prevalence (%)	Reference
Nigeria (Current Study)	15.8	Current Meta-Analysis
Ghana	8.2	Labi et al. (2019)
Ethiopia	14.9	Maikel et al. (2020)
USA	4.0	CDC (2021)
Europe (EU/EEA)	5.5	ECDC (2018)

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