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Demographic Patterns and Clinical Impact of Nosocomial Pseudomonas, Proteus, and Acinetobacter Infections in Yenagoa Hospitals: Evidence for Targeted Infection Control

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Abstract

Objectives: The primary objectives is to examine the demographic patterns and clinical Impact of Nosocomial Pathogens with a focus on pseudomonas, proteus, and acinetobacter for targeted infection control.

Methods: A total of 200 patients from three healthcare facilities in Yenagoa were included. Demographic data were collected, and clinical specimens were obtained from various sites, including wound swabs, urine, uterine catheter tips, ear, and eye swabs. Phenotypic identification of bacterial isolates was conducted to determine the prevalence and distribution of pathogens. Data were analyzed to identify the most common pathogens and their association with demographic variables and specimen types.

Results: The study population consisted of 60.5% males and 39.5% females, with middle-aged adults (31–40 years) representing the largest age group (32%). Wound swabs and urine samples were the predominant specimen types, constituting 44% and 30% of samples, respectively. Pseudomonas spp. was the most prevalent pathogen, accounting for 22% of isolates, followed by Proteus and Alcaligenes at 19% each. Acinetobacter spp. had a prevalence of 16.5%, raising concerns due to its multidrug resistance, particularly in high-risk wards like the ICU. The distribution of pathogens highlighted the diversity of Gram-negative bacteria contributing to nosocomial infections across different wards.

Conclusion: This study underscores the prevalence of nosocomial pathogens in hospital settings, with a high representation of multidrug-resistant organisms, particularly in critical care units. The findings suggest that infection control measures should be directed towards high-risk areas and patient demographics, with a focus on pathogen-specific interventions to mitigate the spread of resistant bacteria. Recommendation: Healthcare facilities should implement enhanced infection control protocols, including targeted surveillance in high-prevalence areas such as ICUs and surgical wards, and emphasize antimicrobial stewardship to manage multidrug-resistant pathogens. Additional strategies should include environmental sanitation, hand hygiene, and age-specific infection prevention efforts to reduce transmission in vulnerable patient populations. Significance Statement: This study highlights critical patterns in nosocomial infections that are essential for shaping infection control policies and resource allocation in healthcare settings. By detailing the demographic trends, pathogen types, and specimen associations with infection risks, the findings provide a foundational basis for developing effective, evidence-based infection prevention and control strategies to improve patient outcomes and hospital safety.

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Demographic Patterns and Clinical Impact of Nosocomial Pseudomonas, Proteus, and Acinetobacter Infections in Yenagoa Hospitals: Evidence for Targeted Infection Control

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Abstract

Rationale: Nosocomial infections remain a significant source of morbidity and mortality in healthcare settings, exacerbated by the rise in multidrug-resistant pathogens. This study was conducted to analyze the demographic characteristics, types of clinical specimens, and pathogen prevalence among hospitalized patients in Yenagoa, providing data to inform targeted infection control strategies. **Objectives:** The primary objectives is to examine the demographic patterns and clinical Impact of Nosocomial Pathogens with a focus on *pseudomonas, proteus,* and *acinetobacter* for targeted infection control. **Methods:** A total of 200 patients from three healthcare facilities in Yenagoa were included. Demographic data were collected, and clinical specimens were obtained from various sites, including wound swabs, urine, uterine catheter tips, ear, and eye swabs. Phenotypic identification of bacterial isolates was conducted to determine the prevalence and distribution of pathogens. Data were analyzed to identify the most common pathogens and their association with demographic variables and specimen types. **Results:** The study population consisted of 60.5% males and 39.5% females, with middle-aged adults (31–40 years) representing the largest age group (32%). Wound swabs and urine samples were the predominant specimen types, constituting 44% and 30% of samples, respectively. *Pseudomonas spp.* was the most prevalent pathogen, accounting for 22% of isolates, followed by *Proteus* and *Alcaligenes* at 19% each. *Acinetobacter spp.* had a prevalence of 16.5%, raising concerns due to its multidrug resistance, particularly in high-risk wards like the ICU. The distribution of pathogens highlighted the diversity of Gram-negative bacteria contributing to nosocomial infections across different wards. **Conclusion:** This study underscores the prevalence of nosocomial pathogens in hospital settings, with a high representation of multidrug-resistant organisms, particularly in critical care units. The findings suggest that infection control measures should be directed towards high-risk areas and patient demographics, with a focus on pathogen-specific interventions to mitigate the spread of resistant bacteria. **Recommendation:** Healthcare facilities should implement enhanced infection control protocols, including targeted surveillance in high-prevalence areas such as ICUs and surgical wards, and emphasize antimicrobial stewardship to manage multidrug-resistant pathogens. Additional strategies should include environmental sanitation, hand hygiene, and age-specific infection prevention efforts to reduce transmission in vulnerable patient populations. **Significance Statement:** This study highlights critical patterns in nosocomial infections that are essential for shaping infection control policies and resource allocation in healthcare settings. By detailing the demographic trends, pathogen types, and specimen associations with infection risks, the findings provide a foundational basis for developing effective, evidence-based infection prevention and control strategies to improve patient outcomes and hospital safety.

Keywords: Nosocomial infections; Multidrug-resistant pathogens; Infection control; Phenotypic pathogen identification; Pseudomonas prevalence; Healthcare-associated infections (HAIs); Clinical specimen; Gram-negative bacterial; Demographic infection patterns; Antimicrobial stewardship.

1. Introduction

Pseudomonas aeruginosa is a very adaptable pathogen, and its presence in healthcare environments constitutes a serious threat because of its high level of resistance to antibiotics and the ensuing morbidity, especially among vulnerable patients in ICUs. This pathogen has thrived in hospital water systems, equipment, and other surfaces that serve as infection conduits for immunocompromised patients [1-3]. Thus, the Pseudomonas infection has presented clinicians with complicated clinical scenarios, with scanty therapeutic options, hence creating a dire need for an effective infection control strategy that can minimize transmission. Adding to the problem of the prevalence of infections by Pseudomonas aeruginosa in healthcare facilities, a huge economic burden is placed on healthcare systems. Actually, the technical difficulty in treating these infections often means extended stays in hospitals and the administration of costly and advanced antibiotics, which many facilities in developing countries can ill afford [4-11]. In Nigeria, the prevalence and resistance patterns can be better understood in order to devise specific strategies to meet regional infection control needs. This may go a long way in mitigating some of the costs associated with the infections, as well as improving patient outcomes by supporting preventive measures. Apart from health care costs, infection with Pseudomonas presents unique clinical challenges due to rapid evolution of resistance of the pathogen, which has even given rise to MDR against last-resort antibiotics such as carbapenems [12-14]. This resistance complicates the treatment protocols and adds to the pressure that healthcare providers will go through since the management of these infections requires cautious selection of effective treatment options. Studies emphasize the need for localized research in this respect to address specific resistance profiles in areas such as Yenagoa, Nigeria, where resistance patterns may be different from

broader trends seen in developed countries. While antimicrobial resistance is taken as a concern globally, there is still limited research into the epidemiology of Pseudomonas infections in certain parts of Nigeria. It is indeed true that localized studies are valuable; after all, they take into account regional factors such as environmental ones, and those related to healthcare practices [15-30], which could influence infection rates. These are some of the factors noted in literature to predispose patients to infection: use of catheters, prolonged hospital stay, and admission to the intensive care unit. Further, identification of particular regional factors in Yenagoa could enhance the effectiveness of infection control measures within the region.
This, in turn, helps enhance higher-order initiatives such as antimicrobial stewardship and infection prevention through a better understanding of the infection trends Pseudomonas causes. The knowledge regarding the prevalence and resistance pattern of the Pseudomonas infection among hospitals within Yenagoa will ensure proper designing of specific programs toward the reduction of infection spread and promoting hygiene practices [31-42]. These efforts will facilitate resource allocation to high-priority areas and improve region-specific protocols that effectively reduce transmission of the drug-resistant infection in healthcare facility settings.

Such efforts to combat the rise of resistant infections are in line with global health efforts to reduce antimicrobial resistance. WHO time and again has reiterated the need to contain the spread of resistant pathogens, since they have turned diseases that are otherwise not life-threatening into fatal ones [3, 4 12]. Data on the epidemiology and risk factors of Pseudomonas infections from Nigeria can provide necessary information for international collaboration in the discovery of new effective therapies and stringent infection control policies. This work, therefore, tries to fill in the gaps in knowledge about the demographic patterns and clinical impact of nosocomial pathogens with a focus on *pseudomonas, proteus,* and *acinetobacter* for targeted infection control from the health facilities in Yenagoa. Localized resistance patterns need to be understood, as they may not always reflect global trends in data due to variations in healthcare structure and patient characteristics, among other environmental factors [1, 5, 6, 17]. Identification of such factors will help to apply appropriate infection control measures that precisely address risks in that region and enhance the quality of patient treatment. This research has objectives well beyond the demographic patterns and clinical impact of nosocomial pathogens; it also hopes to provide insights from which concrete recommendations can be gleaned by hospital administrators and healthcare providers on how best to update policies for the management of Pseudomonas infections. For example, identification of specific risk factors among hospitals in Yenagoa may inform the development of infection prevention strategies relevant to local healthcare challenges, since resources may be limited and practical and targeted interventions are likely to be most useful [2, 3, 33]. The ultimate aim, therefore, of such research could be to bring better practices in infection control and quality health care by the health care giver and policy makers and to the patients. Detailed analysis of Pseudomonas prevalence and its associated risks may provide necessary information about appropriate strategies to potentially reduce nosocomial infection rates, therefore enhancing resources utilization in hospitals within Nigeria [4, 13, 14]. These findings can also set the basis for extended research across other parts of the country, contributing to the much-needed constant flow of new knowledge in the fight against this growing global problem of resistant infections. This study, therefore, provides the much-needed epidemiology of the prevalence of infection by Pseudomonas in Yenagoa with contextually relevant information for healthcare providers working in Nigeria. The locally focused research approach provides a bridge from international guidelines to the realities of healthcare at the local level and forms a basis for appropriate approaches in the management of multi-drug-resistant Pseudomonas aeruginosa infection in Nigerian healthcare settings.

2. Materials and Methods

2.1 Study Design

A cross-sectional study design was utilized, incorporating simple random sampling to achieve a representative sample of clinical isolates from patients hospitalized within the Yenagoa metropolis. This design was chosen to capture the prevalence and risk factors associated with Pseudomonas species in nosocomial infections among Gram-negative isolates, aligning with the study's objectives to identify potential patterns and risk factors within hospital settings.

2.2 Study Area

The study was conducted in Yenagoa, the capital of Bayelsa State in Southern Nigeria. Yenagoa is located at Latitude 4° 55' 29"N and Longitude 6° 15' 51"E, covering 706 km². Known as the primary urban area of Bayelsa, Yenagoa has evolved from a traditional fishing community to a diverse economic hub influenced by the petroleum and natural gas industries. According to census data, Yenagoa's population was 352,285 in 2006, with projections suggesting an increase to approximately 524,400 individuals by 2022 [43]. The study was multi-centered, covering three major healthcare facilities: Federal Medical Centre Yenagoa (FMCY), Diete-Koki Memorial Hospital, and Family Care Hospital. These facilities represent a mix of federal, state, and private healthcare, each catering to over 100 patients daily and providing an appropriate setting to study nosocomial infections.

2.3 Study Population

The study population included inpatients suspected of contracting nosocomial Pseudomonas infections, defined as infections manifesting after 48 hours of hospital admission. Patients were recruited from various wards between July 2022 and June 2023. Inclusion criteria were established to specifically target nosocomial cases, and samples were obtained from patients presenting clinical symptoms indicative of infection.

2.4 Sample Size Determination

The sample size was calculated using the formula by Naing *et al.* [44]:

$$n=\frac{Z^2 * P * (1-P)}{e^2}$$

Where:

- Z = standard score for a 95% confidence interval (1.96)
- P = expected prevalence of Pseudomonas aeruginosa in clinical isolates (13.6% or 0.136) [45]
- e = margin of error (5% or 0.05)

The calculation yielded an estimated sample size of 177; however, for greater statistical power, a total of 200 isolates were obtained for analysis.

2.5 Ethical Considerations

Ethical approval for this study was granted by the ethics committees of Federal Medical Centre Yenagoa, Diete-Koki Memorial Hospital, and Family Care Hospital. Informed consent was obtained from all patients before sample collection, and participant confidentiality was strictly maintained throughout the study, with data anonymized by assigning unique serial numbers to each participant.

2.6 Data Collection

Data on patients' socio-demographic characteristics and relevant clinical information were collected via structured forms administered by laboratory staff in each hospital. Forms excluded patient names, using coded identifiers to maintain confidentiality. Each form's unique serial number was also marked on nutrient agar slants to align patient information with sample data accurately.

2.7 Specimen Collection and Processing

From July 2022 to June 2023, 200 non-lactose fermenting Gram-negative isolates were collected from urine, wound swabs, ear and eye swabs, and other relevant samples from inpatients. These specimens were processed in nutrient agar slants and transported bi-weekly to a designated microbiology laboratory. If immediate processing was not feasible, isolates were stored at 4°C. Identification followed standard morphological and biochemical criteria to confirm the presence of Pseudomonas species among collected samples.

2.8 Identification of Pseudomonas Isolates

2.8.1 Culture and Gram Stain

Isolates were first cultured on MacConkey agar plates and incubated overnight at 37°C. Gram staining was conducted to observe cellular morphology, grouping, and Gram reaction, with isolates showing Gram-negative bacilli being considered for further testing.

2.8.2 Cetrimide Selective Medium

Cetrimide agar, containing 0.1% cetrimide, was used to selectively inhibit growth of non-Pseudomonas species [46]. Non-lactose fermenting, Gram-negative isolates were plated on cetrimide agar and incubated at 37°C for 24 hours. Colonies exhibiting blue-green to green pigmentation and fluorescence under ultraviolet light were presumptively identified as Pseudomonas aeruginosa.

2.8.3 Biochemical Characterization

To confirm Pseudomonas identification, several biochemical tests were performed:

i. Urease Test: Conducted on Christensen's urea agar slants to detect urease production.
ii. Citrate Utilization Test: Performed on Simon citrate agar to assess the ability to utilize citrate as a sole carbon source.
iii. Catalase Test: Involved adding hydrogen peroxide to bacterial colonies and observing bubble formation, indicative of catalase activity.
iv. Oxidase Test: Performed using Whatman No. 1 filter paper soaked in oxidase reagent to detect cytochrome oxidase enzyme activity.
v. Growth at 42°C Test: Conducted to differentiate Pseudomonas aeruginosa from other

non-fermentative bacteria.

2.9 Antibiotic Susceptibility Testing

The susceptibility of Pseudomonas isolates to antibiotics was tested using the Kirby-Bauer disk diffusion method in line with CLSI standards. Discs impregnated with various antibiotics, including fluoroquinolones, cephalosporins, monobactams, carbapenems, and colistin, were used to evaluate resistance profiles. The zone of inhibition around each disc was measured, with results interpreted according to CLSI breakpoints [47].

3. Results

3.1 Socio-demographic and Clinical Characteristics of Study Population in Nosocomial Infection Analysis.

Table 1 show the study population comprised 200 individuals, with a gender distribution showing that males were more frequently represented than females. Specifically, 121 participants (60.5%) were male, while 79 participants (39.5%) were female, illustrating a nearly 3:2 ratio in favor of male patients. This gender disparity may be relevant in understanding risk or prevalence patterns associated with nosocomial infections in the studied population. In terms of age, the majority of participants were between 31 and 40 years old, representing 32% of the total sample. This was followed by the 41 to 50-year age group, accounting for 22.5% of the population, and the 51 to 60-year group, which comprised 21.5%. Younger participants (under 20 years) were relatively few, making up only 10% of the sample, while those aged 21 to 30 made up 14%. The distribution indicates that middle-aged adults were most commonly represented in this study, which may reflect demographic trends in hospital admissions. The clinical specimens collected for analysis varied, with wound swabs being the most frequent, representing 44% of all samples. Urine samples were also common, comprising 30% of the specimens. Other samples included uterine catheter tip samples (20%), ear swabs (4%), and eye swabs (2%). The predominance of wound and urine specimens suggests that Pseudomonas infections may be more common or more easily detectable in these types of samples among hospitalized patients. The isolates sampled from patients admitted in various wards of the selected facilities had the highest proportion was from the male ward, with 33.5% of the patients, followed by the intensive care unit (ICU) with 20% and the surgical ward with 19%. The female ward accounted for 17.5% of participants, while smaller proportions were from the children's ward (8%) and the special care baby unit (2%). This distribution could reflect varying infection rates or hospital stays associated with specific wards, particularly those like the ICU, where patients may be at a higher risk of nosocomial infections. Lastly, the study was conducted across three major healthcare facilities in Yenagoa. The Federal Medical Centre Yenagoa had the highest representation, with 40.5% of participants receiving care there. Family Care Hospital accounted for 30.5% of patients, while Diete-Koki Memorial Hospital comprised 29%. This relatively even distribution among facilities helps ensure the data reflects a comprehensive view of nosocomial infections across different types of healthcare institutions in the region as shown in Table 1.

Table 1: Socio-Demographic Data of the Subjects

Variable	Frequency (N)	Percentage (%)
Gender		
Male	121	60.5
Female	79	39.5
Total	**200**	**100**
Age		
<20	20	10.0
21 – 30	28	14.0
31 – 40	64	32.0
41 – 50	45	22.5
51 – 60	43	21.5
Total	**200**	**100**
Clinical Specimen		
Urine	60	30
Ear Swab	8	4.0
Eye Swab	4	2.0
Wound Swab	88	44.0
Uterine Catheter tip	40	20.0
Total	**200**	**100**
Ward		
Male Ward	67	33.5
Female Ward	35	17.5
Intensive Care Unit	40	20.0
Special Care Baby Unit	4	2.0
Children Ward	16	8.0
Surgical Ward	3.8	19.0
Total	**200**	**100**
Facility		
Federal Medical Centre Yenagoa	81	40.5
Diete-Koki Memorial Hospital	58	29,0
Family Care Hospital	61	30.5
Total	**200**	**100**

3.2 Prevalence and Implications of Gram-Negative Pathogens in Nosocomial Infections: A Focus on Pseudomonas, Proteus, and Acinetobacter Species

Following phenotypic identification, among the 200 clinical isolates analyzed in this study, *Pseudomonas* species exhibited the highest prevalence, accounting for 22% of all positive samples. The prominence of *Pseudomonas* spp. aligns with its well-known role as a leading cause of nosocomial infections, often associated with significant morbidity in healthcare settings. This finding underscores the importance of targeted interventions for *Pseudomonas* in hospital environments where the pathogen is prevalent. *Proteus* and *Alcaligenes* species were also commonly detected, each representing 19% of the isolates. Both species are notable for their ability to persist in hospital settings, with *Proteus* often associated with urinary tract infections and *Alcaligenes* known for causing opportunistic infections in immunocompromised individuals. Their similar prevalence suggests a need for surveillance and control measures for both pathogens to reduce their impact on patient health outcomes. *Acinetobacter* species ranked next, with a prevalence of 16.5% in the clinical isolates. This pathogen is particularly concerning due to its ability to develop multidrug resistance and its association with severe infections in critically ill patients. The relatively high prevalence of *Acinetobacter* in this study highlights the ongoing challenge it poses for infection control practices, especially in intensive care and other high-risk wards. Other detected pathogens included *Aeromonas* species, present in 9% of the isolates, and *Providencia* species, found in 6%. *Aeromonas* is typically linked to infections in aquatic environments but can also cause infections in hospital settings, particularly in patients with weakened immune systems. *Providencia* spp., although less common, is known for its resistance to certain antibiotics, making its presence notable even at a lower prevalence. Finally, *Stenotrophomonas maltophilia* and atypical *Escherichia coli* were the least prevalent pathogens, with 4.5% and 4% prevalence, respectively. *Stenotrophomonas maltophilia* is often resistant to a broad spectrum of antibiotics, which presents challenges for treatment. Atypical *Escherichia coli*, although less frequently encountered, remains a relevant nosocomial pathogen, particularly in patients with compromised immunity. The presence of these pathogens, albeit at lower rates, emphasizes the diversity of Gram-negative organisms contributing to nosocomial infections and the need for comprehensive infection control strategies to address a wide range of microbial threats as shown in Table 2 below.

Table 2: Distribution of Bacterial Species among Collected Isolates

Pathogen	Positive (N)	Prevalence (%)
Acinetobacter spp	33	16.5
Pseudomonas spp	44	22
Atypical Escherichai coli	8	4
Providencia spp	12	6
Proteus spp	38	19
Alcaligenes spp	38	19
Aeromonas	18	9
Stenotrophomonas maltophilia	9	4.5
Total	200	100

4. Discussion

4.1 Socio-Demographic Distribution and Clinical Characteristics of Nosocomial Pseudomonas aeruginosa Infections

In the current study, there was a preponderance of male patients, in agreement with most recent reports. Alhussainy *et al.* [1], for example, reported higher prevalence of nosocomial Pseudomonas aeruginosa infections among male than female patients. The observed difference in prevalence was believed to be due to gender-related variation in health-seeking behavior and hospital admissions. This is further supported by studies such as Alabi *et al.* [2] and Lee *et al.* [12], which clearly record that in certain wards, male-dominated demographics may have a bearing on the infection pattern. Perhaps this is because males usually have longer or more complex medical histories. This pattern would be important in targeted infection prevention strategies in such wards with high male admissions. Age-wise, the present study recorded most infections among the 31-50 years age group, which agrees with the findings of Alabi *et al.* [2] and Tzeng *et al.* [3], who found middle-aged adults were one of the more risky groups. These studies indicate that middle-aged adults are typically burdened with comorbidities and lifestyle-related health risks, hence becoming more susceptible to infections like Pseudomonas in hospitals. These studies also sometimes, like Sharma *et al.,* [4] reflect higher prevalence even among older populations, especially when patients in the ICUs are included. This divergence underlines heterogeneity of infection risks with age across hospital settings and has implications for screening and monitoring during life. Clinical specimen distribution in this present study revealed a high rate of Pseudomonas detection from wound and urine samples, which agrees with the findings of Saderi *et al.* [48] and Ranjbar *et al.* [5] who reported a high infection rate from wounds, especially among patients undergoing invasive procedures. This is in agreement with the literature, where it is indicated that wound sites present an easy portal of entry for any pathogen among patients that are hospitalized, especially when compounded by health conditions. The high load in urine samples, as described by Chen *et al.,* [6] underlines the dire need for more stringent sterility and post-procedural care for catheterized patients to prevent any chances of infection. Regarding the ward-based distribution, the present study showed the prevalence to be higher in the male ward, followed by the ICU and surgical ward. This agrees with the findings of Sharma *et al.* [4] and Lee *et al.* [12], where ICUs recorded high rates in all the studies due to immunocompromised states and frequent use of invasive devices. Tzeng *et al.* [3] also reported surgical wards, where the patients' exposure to pathogenic organisms is increased, as contributing to increased infection rates. This trend indicates the need for developed and strengthened infection control policies in wards specifically at a higher risk of nosocomial infection due to intense patient care. Finally, the near-equal distribution across the three study facilities agreed with Wu *et al.* [49] and Tsai *et al.* [50], who documented high prevalence rates across diverse clinical facilities, underlining that nosocomial Pseudomonas infections constitute a very current problem. The equal distribution would appear to show that infection risk factors are not limited to the type of facility considered here, hence pointing to the dire need for uniform infection control protocols. These findings were in concert with the greater findings pointing out the need to address Pseudomonas infections comprehensively, using multi-setting approaches that take into account demographic and procedural variables influencing infection dynamics across wards and hospitals.

4.2 Prevalence and Clinical Significance of Nosocomial Pathogens

These findings are therefore in line with literature on the prevalence and clinical significance of various pathogens of nosocomial infection, highly represented by Pseudomonas species to constitute one of the major causes of hospital-acquired infections. Other studies confirm the high prevalence of Pseudomonas aeruginosa in healthcare settings, with emphasis on critical care areas, including intensive care units, where there is an increased risk of infection among patients. Lee *et al.* [12] identified that Pseudomonas accounts for a high percentage of infections in high-risk patient groups, indicating its high virulence and resistance. The latter again will adequately enhance the justification for stringent infection control against Pseudomonas, considering its prevalence and the higher morbidity that it causes among patients in hospitals. Prevalence of Proes species, constituting 19% of the current study's isolates, similarly agrees with Sharma *et al.* [4] and Huang *et al.* [33], who found these pathogens to be commonly associated with nosocomial infections, especially in UTIs and among immunocompromised patients. Liu *et al.* [13] presented the resilient hospital settings in the wards with high caseloads due to UTI, emphasizing its adaptation in a hospital setting. Both Proteus and Alcaligenes were always reported for their opportunistic natures of infection, and Chen *et al.,* [51] also presented the same observation while detecting these pathogens in immunocompromised patients in 2019. Thus, both pathogens are represented to have almost similar prevalence rates in this study which requires addressing both pathogens under hospital infection control policies.

This agrees with the current study finding of 16.5% prevalence of Acinetobacter species, observations by Saderi *et al.* [32], who found that Acinetobacter infections have become particularly challenging because of their resistance to multiple drugs, especially in the intensive care units. Lee *et al.* [52] also stressed that this pathogen is associated with increased mortality rates in sick patients; thus, its targeted management in ICUs and other high-risk settings needs to be emphasized. According to Wu *et al.* [49], Acinetobacter infections require active management of resistance due to the pathogen's high resilience and persistence in clinical environments, a fact which supports the conclusion by Sharma *et al.*, [4]. The convergence of findings from these studies points towards an imperative for expansive infection control measures concerning the mentioned bacterium in high-risk hospital settings. Other less common causative agents, such as in the current study, are Aeromonas (9%) and Providencia (6%), that also agree with pointing to these organisms' involvement in nosocomial infections. Aeromonas had been pointed out to be an opportunistic infection agent by Lee *et al.* [12] and Huang *et al.* [33] especially in immunocompromised patients. Similarly, Liu *et al.* [13] have discussed the adaptive resistance mechanisms of Providencia; thus, lower prevalence rates agree with this observation. Although less common, the presence of these pathogens underlines the range of Gram-negative bacteria responsible for hospital-acquired infection by Sharma *et al.* [4]. The inclusion of such organisms in this study thus represents the requirement for broader approaches to infection prevention strategies. The final results from the current study stand at 4.5% for Stenotrophomonas maltophilia and 4% for atypical Escherichia coli, findings similar to those by Chen *et al.* [6] in their analysis of nosocomial infections among immunocompromised patients. The studied resistance patterns of Stenotrophomonas by Park *et al.* [53] pose further challenges to health workers, especially with its adaptabilities in treatment. Further, Saderi *et al.* [32] have pointed out the clinical relevance of even low-prevalence pathogens in hospital settings, identifying those that affect the most vulnerable ulation. The detection of these in the current study supports the general call for broad and adaptive infection control policies in hospitals given a wide range of microbial risks. Thus, these findings are in concert with the general literature, which has focused on the importance of Pseudomonas, Proteus, and Acinetobacter in nosocomial infection. Wang *et al.* [14] emphasize that such highly prevalent organisms would require tailored infection control measures because of their adaptability and resistance profiles. Moreover, the presence of less common pathogens such as Aeromonas and Stenotrophomonas underlines the need for vigilance to prevent nosocomial infections across a broad spectrum of Gram-negative organisms. Past research by scholars such as Sharma *et al.* [4] and Chen *et al.* [6] further underlines the tailored strategies of hospital infection control in managing the diverse range of nosocomial patient outcomes.

5. Conclusion

This study will enlighten the demographic distribution, specimen types, and microbial prevalence of nosocomial infections in selected health facilities. The predominance of male patients and middle-aged adults probably underlines some demographic trends in nosocomial infections which could be pegged on specific risk factors thus requiring further investigation. The high prevalence of wound and urine specimens among the clinical isolates identifies them as the most important sites of infection, with the most common swabs taken from wounds and followed by samples of urine. These findings further support the implementation of monitoring and preventive measures for infection at body sites with higher probabilities of infection, such as wounds and urinary systems, in order to contain the risk of pathogen transmission in healthcare settings. *Pseudomonas spp*. remains the most common isolated pathogen, in line with its recognized role in nosocomial infections and resulting morbidity. This follows closely after Proteus and Alcaligenes, which also turn out to be highly present in hospital settings, especially in susceptible populations. Acinetobacter remains a significant concern, with noted multidrug resistance, especially in critical care settings such as the ICU.

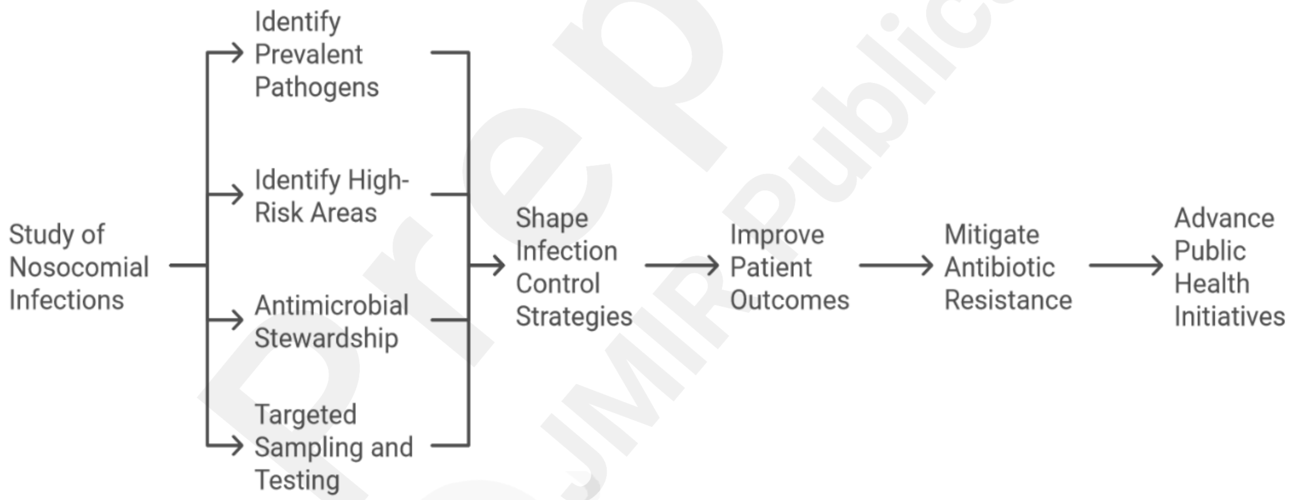
The pathogen diversity includes less prevalent but clinically relevant organisms such as Aeromonas and Providencia, which extend the complexity of the Gram-negative bacterium leading to nosocomial infection. This therefore indicates an overall need for pathogen-specific control measures across healthcare facilities with regard to the management of infection risks. The overall findings indicate that the trend of nosocomial infection cases is varied with regards to the distribution by patient demographics, types of clinical specimens, and the distribution of pathogens across different hospital wards. Infection cases were concentrated in the male ward, the intensive care unit, and the surgical ward; this signifies the strategic heightening of infection control measures in these high-risk areas. The present study identifies the main demographic, pathogen type, and facility-level variances that should be highlighted in formulating evidence-based infection control policies which will meet the peculiar needs of a wide range of hospital settings.

6. Recommendations

Health facilities should also adopt targeted surveillance systems for high-risk pathogens like Pseudomonas spp., Proteus spp., and Acinetobacter spp. in an attempt to reduce nosocomial infection incidence. This may be achieved by monitoring infection rates regularly in specific wards that are usually more prone to being victimized by such bacteria, such as the Intensive Care Unit and the male ward. The dissemination of multidrug-resistant organisms could also be contained by routine screening for high-risk patients and instituting systematic infection control protocols. This would be further supported by training healthcare personnel in infection control practices tailored for such wards. However, the establishment of antimicrobial stewardship programs in hospitals is needed to limit excessive use of antibiotics, hence bringing down the selective pressure that would result in the emergence of multidrug-resistant microorganisms. Restrictive policies regarding certain antibiotics along with patient-specific treatment may greatly help in dealing with resistant pathogens such as Acinetobacter and Stenotrophomonas maltophilia. Of course, enhanced environmental cleaning, hand hygiene, and sterilization practices will also have to be carried out to reduce the transmission of nosocomial pathogens, particularly for those areas where cross-contamination is going to be easy, such as wound and urinary specimens. Based on the demographic insights provided in the paper, for instance, by paying closer attention to middle-aged adults since they form a more significant proportion of hospitalized patients who are at risk of nosocomial infections, healthcare facilities may, finally, derive benefits from focused infection control practices. Age and gender-specific infection control practices can be implemented simultaneously with general facility-wide guidelines geared toward minimizing infection prevalence. There is also the need for hospitals to further develop isolation precautions and resource allocation to support these focused interventions in high-prevalence wards.

7. Significance Statement

This study contributes to nosocomial infection patterns, yielding valuable data that could shape infection control strategies in hospital settings. The present study has identified Pseudomonas and other prevalent pathogens, the most affected wards, and demographic groups on which a basis can be provided to healthcare administrators for prioritizing infection control resources effectively. The study has also brought out that targeted intervention in high-risk areas, such as ICUs and male wards, can substantially influence nosocomial infection rates in the reduction and improvement of patient outcomes. Additionally, the study has pointed out that management related to multidrug-resistant pathogens, such as Acinetobacter, has to be in conformation with antimicrobial stewardship, applying personalized treatment strategies. In this aspect, findings stress the application of an antibiotic policy that minimizes resistance development due to high and continuous antibiotic application, considered a challenge in various healthcare facilities around the world. It is at this juncture that research urges sustainability in infection control practices impeding the spread of resistant pathogens through the healthcare facility by providing information on the frequency of antibiotic-resistant organisms in wards and in specific patient demographics. Finally, this wide-dimensional approach of the study to analyze nosocomial infection in various clinical specimens provides a holistic approach toward infection control. Data clearly delineate that wound and urine specimens are among the major areas from which nosocomial pathogens originate. This further identifies the need for targeted active sampling and test ordering policies. By targeting these specimen types, healthcare providers can detect and respond to infections more effectively for the benefit of advancing patient safety and supporting public health goals related to infection control. Thus, graphically it is represented (Figure 1 below) as:



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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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