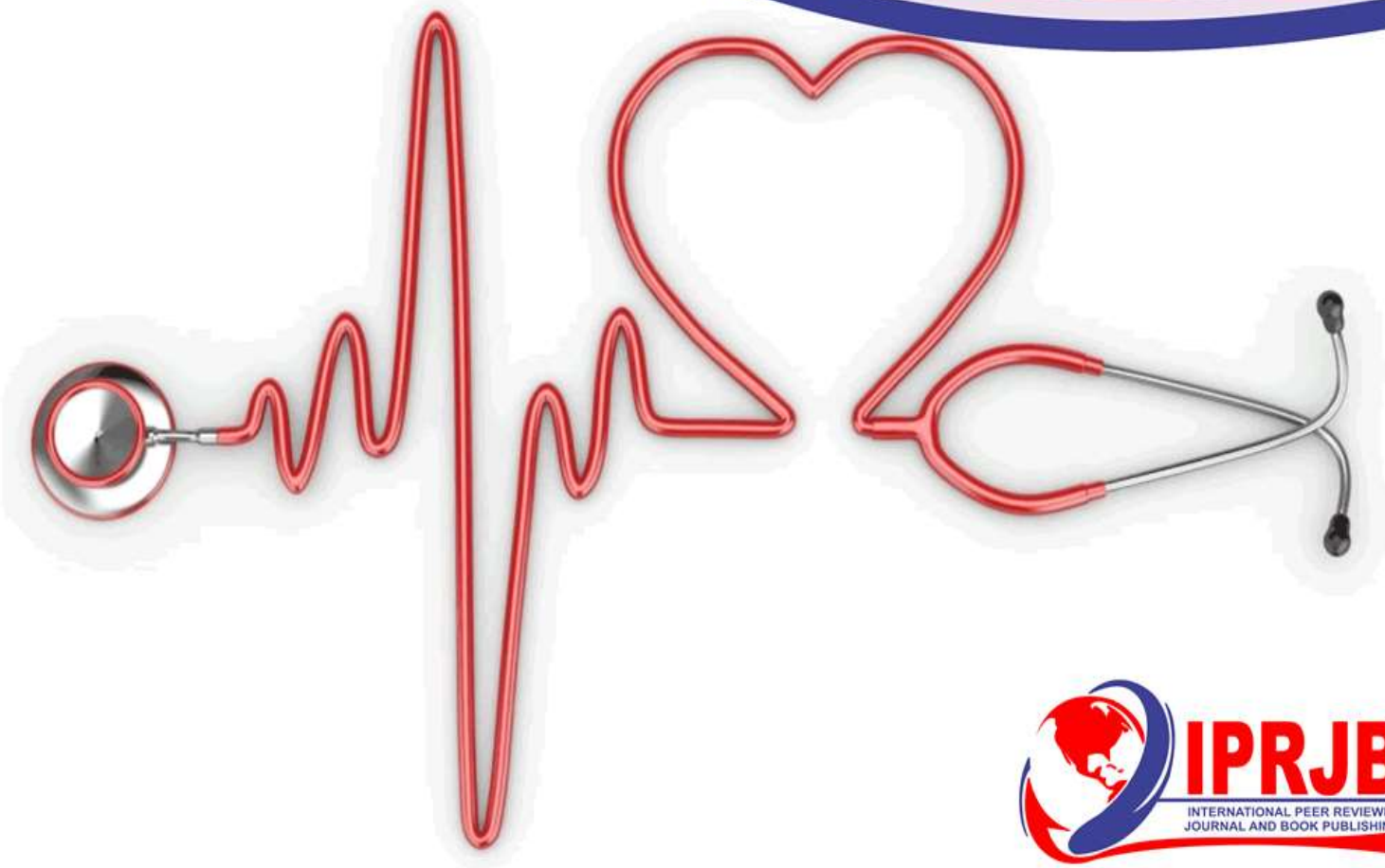
Journal of
Health, Medicine and Nursing
(JHMN)

Predictors of Nosocomial Infections among Geriatric Patients in the Internal Medicine Department of the University Teaching Hospital of Butare (CHUB), South, Huye, Rwanda

Albert Busumbigabo, Dr. Joseph Niyonzima, Dr. Thacien Nduwayo, Mr. Theogene Bahizi, Mrs. Marie Josée Niyibikora, Dr. Evariste Mushuru and Mr. Christian Tunga



IPRJB
INTERNATIONAL PEER REVIEWED JOURNAL AND BOOK PUBLISHING

Journal of Health, Medicine and Nursing
ISSN 2520-4025 (Online)
Vol.10, Issue 5. No.5, pp 77 - 86, 2024

www.iprjb.org

Predictors of Nosocomial Infections among Geriatric Patients in the Internal Medicine Department of the University Teaching Hospital of Butare (CHUB), South, Huye, Rwanda

Albert Busumbigabo[1], Dr. Joseph Niyonzima[1], Dr. Thacien Nduwayo[1], Mr. Theogene Bahizi[1], Mrs. Marie Josée Niyibikora[1], Dr. Evariste Mushuru[1]
[1]Clinical Research Team, University Teaching Hospital of Butare (CHUB), Huye-Rwanda
Mr. Christian Tunga[2]
[2]University of Rwanda/School of Medicine and Pharmacy, Huye-Rwanda

Article History

Received 12th September 2024

Received in Revised Form 16th October 2024

Accepted 26th November 2024

How to cite in APA format:

Busumbigabo, A., Niyonzima, J., Nduwayo, T., Bahizi, T., Niyibikora, M., Mushuru, E., & Tunga, C. (2024). Predictors of Nosocomial Infections among Geriatric Patients in the Internal Medicine Department of the University Teaching Hospital of Butare (CHUB), South, Huye, Rwanda. *Journal of Health, Medicine and Nursing*, *10*(5), 77–86. https://doi.org/10.47604/jhmn.3097

Abstract

Purpose: Nosocomial infections pose a significant burden worldwide, particularly in resource-limited settings. This study aimed to determine predictors of nosocomial infections among geriatric patients at the University Teaching Hospital of Butare (CHUB) in Rwanda.

Methodology: A quantitative cross-sectional cohort study over seven months included participants admitted to CHUB's Internal Medicine department from July 2023 to January 2024 with the aim to determine the Nosocomial infections predictors among elderly aged 61 years and above. The target sample size was 313, but a census approach with 400+ participants was used. Data collection involved physician examinations, laboratory testing, interviews, facility observations, specimen culture, antimicrobial susceptibility testing, and logistic regression analyses.

Findings: The study included 206 participants who were screened infection-free at admission, predominantly from Southern Province (85%) and female (56%), with a median hospital stay of 3 days. Most were admitted from Kabutare District Hospital (22%) to Internal Medicine (90%). Age distribution peaked at 61 years and above (38.8%) and 60 years and below (61.2%). Unemployment was high (83%), especially among females (60%) and those with low education. Prior 30-day hospitalization occurred in 34%, mainly for non-communicable diseases (41%) and infections (20%). Chronic conditions were reported by 41%, commonly hypertension (37%), other non-communicable diseases (14%), and diabetes (10%). Recent antibiotic use was 23%, primarily ceftriaxone (54%). Urine samples dominated (55%), with prevalent pathogens like Escherichia coli and Staphylococcus species. But more importantly this study demonstrated a strong association between nosocomial infection level and some predictors with significant P values as follows: time of stay (P=0.002), Health Care providers following WHO 5 Moments of hand hygiene (P=0.005), disinfection of medical devices by Health Care providers (P=0.036) and hands washing before taking medicines (P=0.047).

Unique Contribution to Theory, Practice and Policy: The environmental decontamination and antibiotic rotation policies should be implemented to manage Acinetobacter spp. infections. As well hand hygiene adherence and preventive measures for urinary tract infections will address Escherichia Coli infections. Efforts to mitigate the burden of nosocomial infections should prioritize the enhanced surveillance, establishing robust infection tracking systems across healthcare facilities, invest in antimicrobial stewardship and targeted interventions tailoring infection control practices to high-risk groups like geriatric patients.

Keywords: *Nosocomial, Infection, Hospital, Butare, Rwanda*

Journal of Health, Medicine and Nursing
ISSN 2520-4025 (Online)
Vol.10, Issue 5. No.5, pp 77 - 86, 2024
www.iprjb.org

INTRODUCTION

Nosocomial infections, also known as hospital-acquired or healthcare-associated infections, represent a formidable challenge to healthcare systems worldwide [1]. These infections, which develop in patients after admission to healthcare facilities, not only compromise patient safety and quality of care but also result in increased morbidity, mortality, and healthcare costs [2]. The burden of nosocomial infections is particularly concerning in developing countries, where limited resources and suboptimal infection control practices can contribute to higher rates of these preventable infections [3].

The World Health Organization (WHO) defines a nosocomial infection as an infection acquired by a patient during the process of receiving care in a hospital or other healthcare facility, which was not present or incubating at the time of admission [4]. Infections are considered nosocomial if they manifest at least 48 hours after hospital admission, up to 3 days after discharge, or even up to 30 days after an operation or invasive procedure [5]. This definition encompasses a wide range of infections, including surgical site infections, ventilator-associated pneumonia, catheter-related bloodstream infections, and urinary tract infections associated with indwelling catheters [6].

The Internal Medicine department of CHUB, a 500-bed tertiary care facility serving a catchment area of approximately 4 million people, predominantly caters to geriatric patients. With an average of 100 elderly patients admitted monthly, the department represents an ideal setting to investigate the incidence, risk factors, and causative microorganisms associated with nosocomial infections in this vulnerable population. However, data on the burden and predictors of nosocomial infections among geriatric patients in Rwandan healthcare facilities are currently limited, hindering the development of targeted prevention and control strategies.

This study aims to address the knowledge gap by determining the predictors of nosocomial infections among geriatric patients in the Internal Medicine department of CHUB. By identifying the incidence, associated factors, and common pathogens, the study will provide crucial insights to inform the development of evidence-based strategies tailored to the unique needs of elderly patients in Rwandan healthcare facilities.

The University Teaching Hospital of Butare (CHUB) was chosen as a study site due to its critical role in Rwanda's healthcare system and the documented prevalence of healthcare-associated infections there. Studies highlight CHUB as a representative institution for such research because it serves as a major referral hospital, dealing with diverse and complex medical cases, which creates a higher risk for nosocomial infections.

Research conducted at CHUB has revealed significant rates of nosocomial infections about 12.1%, including respiratory infections, surgical site infections, and urinary tract infections. Factors contributing to its selection include the availability of patient data, the high patient load, and existing challenges in infection prevention practices. These conditions make CHUB a valuable setting for studying infection dynamics and intervention strategies in a resource-limited environment.

Problem Statement

Nosocomial infections pose a significant global health problem, affecting both developed and developing nations [1]. According to the WHO, the prevalence of nosocomial infections ranges from 3.6% to 12% in high-income countries and from 5.7% to 19.1% in low- and middle-income nations [6]. The impact of these infections extends beyond individual patient outcomes,

as they also contribute to increased healthcare costs, prolonged hospital stays, and the emergence of antimicrobial resistance, which further exacerbates the burden on healthcare systems [4].

In Rwanda, recent studies have highlighted the alarming prevalence of nosocomial infections in healthcare settings [7]–[10]. A study conducted at the University Teaching Hospital of Butare (CHUB) in 2015 revealed a 12.1% prevalence of nosocomial infections, underscoring the need for robust surveillance and preventive measures [8]. Similarly, at the University Teaching Hospital of Kigali (CHUK), nosocomial infection rates were reported to be approximately 15.1% between 2013 and 2014 [10]. These findings indicate that nosocomial infections are a significant burden across Rwandan healthcare facilities, necessitating immediate action to address this public health issue.

Elderly patients, often referred to as geriatric patients, are particularly vulnerable to nosocomial infections due to their weakened immune systems, multiple comorbidities, and increased exposure to invasive procedures and prolonged hospital stays [11]. As the elderly population continues to grow globally, the burden of nosocomial infections in this high-risk group is expected to rise, further straining healthcare resources and compromising patient outcomes [12].

METHODOLOGY

Study Setting

This study was conducted at the University Teaching Hospital of Butare (CHUB), a 500-bed referral hospital serving a population of approximately 4 million people in its catchment area. The Internal Medicine department at CHUB, which comprises 86 beds, admits around 100 geriatric patients per month.

Study Design and Population

This research employed a quantitative cross-sectional cohort design over a seven-month period. The study population consisted of participants who were admitted to the Internal Medicine department of CHUB with an emphasis to aged 61 years and above during the study period and were free from infections at the time of admission.

Sample Size and Sampling Technique

The sample size was calculated using a single population proportion formula, considering a prevalence of nosocomial infections (NIs) of 15%, an error margin of 3.5%, a power of 80%, and a 95% confidence interval. The resulting minimum sample size was 313 participants. However, to increase the robustness of the findings, a census approach was adopted, aiming to include all geriatric patients admitted during the seven-month study period, with an expected sample size of at least 400 participants.

Participants were recruited using a non-probability sampling technique. Nurses in the Accident and Emergency and Internal Medicine departments were trained to identify and enroll eligible participants upon admission. Every admitted patient was recruited by a physician participating in the study and screened from a current infection.

Data Collection

Upon admission, participants were examined by a physician, and those willing to participate provided signed informed consent. A trained research assistant, a nurse, collected prescribed

laboratory samples (blood, urine, tracheal secretions, and others as needed) for screening and sent them to the CHUB laboratory for testing according to standard procedures.

Nurses conducted interviews with participants to assess their knowledge of infection prevention and control practices, as well as to gather demographic information and vital signs. Healthcare providers were also interviewed to evaluate their knowledge of infection prevention and control best practices, and observations were made regarding health care providers respecting WHO hand hygiene moments and other nosocomial infection predictors.

After hospitalization, participants were monitored by physicians for signs of nosocomial infections. Laboratory testing was ordered for any purulent discharge, abscess, spreading cellulitis at surgical sites, urinary tract infections, respiratory infections, or bloodstream infections. Stool samples or rectal swabs were collected from participants with diarrhea.

Participants transferred to intensive care units or hemodialysis facilities for additional clinical treatment were followed up on, involving healthcare professionals from those units to evaluate system and personnel-related aspects through interviews and observations.

Data Collection Instruments

Blood samples were inoculated into blood culture media immediately to prevent clotting. Stool and rectal swab samples were refrigerated or frozen, depending on the transportation time. Urine samples were collected as clean-catch midstream specimens and processed within two hours or refrigerated if processing was delayed.

Fluid and pus samples were obtained from properly cleaned and prepared tissue or viable wound beds to avoid surface contamination. Respiratory samples were collected by introducing a swab into the throat and scraping epithelial cells and secretions.

Interviews with patients, staff, and observations of facility equipment and materials for preventing NIs were conducted using validated data collection tools.

Laboratory Procedures

Blood culture bottles were inoculated and monitored for bacterial growth using the BD Bactec FX40 system. Positive cultures were subcultured onto non-selective media, and Gram staining, biochemical tests, and antimicrobial susceptibility testing were performed for identification and antimicrobial susceptibility profiling.

Sputum cultures were performed to identify respiratory pathogens causing community-acquired or hospital-acquired pneumonia or bronchopneumonia. Pus and wound specimens were cultured to isolate and identify bacterial etiological agents.

Urine cultures were performed by inoculating blood agar and MacConkey agar plates and incubating for a minimum of 24 hours. Stool cultures were performed using routine media, including blood agar, MacConkey agar, Xylose Lysine Deoxycholate (XLD) or Deoxycholate Citrate Agar (DCA), and Selenite F broth. Additional media were used if Vibrio cholerae was suspected.

Data Analysis

The collected data, including demographic and clinical characteristics, laboratory results, and questionnaire responses, were coded and entered into Epi-Data. Statistical analysis was performed using SPSS software. The prevalence of NIs among geriatric patients was calculated by dividing the number of participants who acquired NIs by the total number of participants in

the sample. Logistic regression analyses were conducted to assess the relationships between potential predictors (medical procedures, staff hygiene practices, patient behavior, and facility factors) and the occurrence of NIs. Multivariable logistic regression models were built using a backward-stepwise approach, with variables included if they had a p-value ≤ 0.25 in the univariable analysis and retained in the final model if their p-value was ≤ 0.05. Odds ratios (ORs) with 95% confidence intervals (CIs) were reported.

Ethical Considerations

The study proposal received ethical clearance from the Institutional Review Board of the University Teaching Hospital of Butare. All participants provided signed informed consent prior to participation. Participation was voluntary, and participants could withdraw from the study at any time without consequence. The study followed ethical principles of anonymity and confidentiality in data handling and reporting.

RESULTS

Demographic Characteristics

The study included 206 participants who were screened infection-free at admission, with 85% of respondents from the Southern Province of Rwanda. The majority (56%) of participants were female. The length of hospital stay ranged from 1 to 123 days, with most respondents (26%) staying for 3 days. The participants were primarily referred from Kabutare District Hospital (22%) and admitted to the Internal Medicine department (90%). The age distribution of participants showed that 38.8% were in the 61 years and above age group, while 61.2% were younger aged 60 years and below. Most participants were not employed (83%), with a higher proportion of unemployed females (60%) compared to males. Regarding economic categories, 43% were categorized as Cat1, 34% as Cat2, and 27% as Cat3. Concerning educational levels, 44% of participants were uneducated, 43% had primary-level education, 10% had secondary-level education, and 3% had tertiary-level education. The majority of participants without education (91%) and those with primary-level education (78%) were unemployed.

Previous Hospitalizations and Chronic Conditions

Approximately 34% of the participants had been hospitalized in the last 30 days, with 69% of those hospitalizations occurring within the last 7 days, 16% within the last 14 days, and 16% within the last 30 days. The main reasons for previous hospitalizations were non-communicable diseases (NCDs) (41%) and infections (20%). Additionally, 41% of participants reported having a known chronic disease, with hypertension (37%), other NCDs (14%), and diabetes (10%) being the most common conditions.

Antibiotic Use and Specimen Analysis

Among the participants, 23% had been on antibiotic therapy within the last 30 days, with ceftriaxone (54%) being the most commonly used antibiotic. Specimen analysis revealed that urine samples dominated (55%), and the prevalent microorganisms were Escherichia coli, Enterobacter species and Staphylococcus species.

Journal of Health, Medicine and Nursing
ISSN 2520-4025 (Online)
Vol.10, Issue 5. No.5, pp 77 - 86, 2024
www.iprjb.org

Multivariate Analysis: Factors Associated With Nosocomial Infections in CHUB

	Variable	N=206(%)	Chi square	P-value
	Time of stay		**6.733**	**0.002**
	<5 days	116 (56.3)		
	5-10 days	50 (24.3)		
	>10 days	40 (14.6)		
	Age level		0.397	0.528
	Aged people (61 and above)	80 (38.8)		
	Young people (60 and below)	126 (61.2)		
	Gender		0.025	0.874
	Female	115 (55.8)		
	Male	91 (44.2)		
	Changing gloves		1.515	0.605
	No	24 (11.7)		
	Yes	182 (88.3)		
	HCP follow 5 steps for hands washing		7.825	**0.005**
	No	193 (93.7)		
	Yes	13 (6.3)		
	HCP follow aseptic measures		2.323	0.127
	No	21 (10.2)		
	Yes	180 (87.4)		
	N/A	5 (2.4)		
	HCP disinfect medical devices		4.053	**0.036**
	No	112 (54.4)		
	Yes	94 (45.6)		
Washing hands before eating			1.135	0.086
No		46 (22.3)		
Yes		160 (77.7)		
Washing hands before taking medicines			**2.173**	**0.047**
No		66 (32.0)		
Yes		140 (68.0)		
Washing hands after toilet?			1.020	0.106
No		61 (29.6)		
Yes		145 (70.4)		
Ward Cleaning every day?			1.020	0.106
No		1 (0.5)		
Yes		205 (99.5)		

Source: Primary Data, 2024

Follow-up analysis showed that 15% of participants had positive results for microorganism species, indicating the presence of nosocomial infections. The prevalence of nosocomial infections was higher among older adults aged 61 years and above (18%) compared to younger participants aged 60 years and below (13%). Among the positive cases, 46% were older adults aged 61 years and above, while 54% were younger participants aged 60 years and below, reflecting the age distribution of the sample. Older adults were primarily infected by Acinetobacter species (7%), Enterobacteria species (14%), Escherichia coli (36%), Klebsiella species (14%), and Staphylococcus species (21%).

Discussion

The present study aimed to determine the predictors of nosocomial infections among geriatric patients admitted to the Internal Medicine department of the University Teaching Hospital of Butare (CHUB) in Rwanda. By employing a quantitative cross-sectional cohort design and a

comprehensive data collection approach, including physician examinations, laboratory testing, interviews, and facility observations, we sought to elucidate the burden and contributing factors associated with these healthcare-associated infections in this vulnerable population.

The key findings of our study revealed a 15% prevalence of nosocomial infections among patients admitted to internal medicine department without a current infection. Notably, this prevalence was higher among older adults aged 61 years and above (18%) compared to those aged 60 years and below (13%). These results align with existing literature highlighting the increased susceptibility of elderly individuals to nosocomial infections due to age-related immune system decline, comorbidities, and higher exposure to invasive procedures and prolonged hospitalizations [13].

Our analysis identified Acinetobacter, Enterobacteria, Escherichia coli, Klebsiella, and Staphylococcus species as the primary pathogens responsible for nosocomial infections in the geriatric population at CHUB. This finding is consistent with previous reports from other healthcare facilities in Rwanda, which have documented similar causative agents associated with nosocomial infections [7]–[10]. However, the specific distribution of pathogens may vary across different healthcare settings and patient populations, underscoring the importance of conducting site-specific surveillance and tailoring prevention strategies accordingly.

Pathogens such as Acinetobacter and Escherichia coli have profound implications in hospital environments, especially concerning geriatric patients. Their prevalence and behavior highlight critical issues in nosocomial infections and antimicrobial resistance (AMR). Acinetobacter, particularly A. baumannii, is known for its ability to survive in a wide range of environmental conditions, including dry surfaces in hospital settings. This adaptability allows it to persist on medical equipment, hospital furniture, and even on hands, facilitating nosocomial infections. Escherichia coli is frequently found in hospital-acquired infections, notably urinary tract infections (UTIs) and bloodstream infections. Its ability to form biofilms on catheters and other medical devices makes it a persistent issue in healthcare. Both pathogens often exhibit multidrug resistance. Acinetobacter has become synonymous with carbapenem resistance, making infections harder to treat. Similarly, ESBL-producing E. coli strains can resist a broad spectrum of antibiotics, leading to limited treatment options and prolonged hospital stays. Geriatric patients are at higher risk due to age-related immune system decline and comorbidities such as diabetes or chronic kidney disease. Their frequent exposure to invasive procedures, such as catheterization or mechanical ventilation, further increases the risk of acquiring infections from these pathogens. Infections caused by Acinetobacter and E. coli are associated with high morbidity and mortality in older adults. For instance, Acinetobacter is a leading cause of ventilator-associated pneumonia in elderly patients, while E. coli UTIs can progress to life-threatening sepsis. The resistance patterns of these pathogens necessitate the use of last-resort antibiotics, such as colistin or tigecycline, which carry risks of nephrotoxicity and other adverse effects. This is particularly concerning for elderly patients, who are more susceptible to drug toxicity due to age-related organ function decline. The presence of Acinetobacter and E. coli in hospital environments underscores the importance of stringent infection control measures, including regular cleaning protocols, hand hygiene, and antimicrobial stewardship programs. Special attention is needed for geriatric care to minimize invasive procedures, ensure early detection of infections, and manage AMR effectively.

Notably, our study revealed that a significant proportion of participants (34%) had been hospitalized within the preceding 30 days, primarily due to non-communicable diseases (41%)

and infections (20%). This finding aligns with previous research suggesting that recent hospitalizations and underlying comorbidities contribute to an increased risk of nosocomial infections, particularly in the elderly population [14]. Furthermore, the high prevalence of chronic conditions such as hypertension (37%), other non-communicable diseases (14%), and diabetes (10%) among our participants may have further compounded their susceptibility to nosocomial infections.

The findings from the study at the University Teaching Hospital of Butare, highlighting geriatric vulnerability to nosocomial infections and the role of pathogens like Klebsiella pneumoniae, align with broader trends observed in other African healthcare settings. Comparative analyses offer deeper insight into the regional dynamics of healthcare-associated infections (HAIs) and the challenges posed by pathogens like Klebsiella.

In Rwanda, the study identified a significant prevalence of nosocomial infections in geriatric patients, with Klebsiella pneumoniae, Escherichia coli, and Acinetobacter spp. being dominant pathogens. Similarly, studies in Nigeria and Kenya have reported high prevalence rates of nosocomial infections in older adults, with Klebsiella pneumoniae commonly implicated in UTIs, bloodstream infections, and ventilator-associated pneumonia [8].

In South Africa, Klebsiella pneumoniae is a leading cause of neonatal and adult HAIs, particularly in ICUs. Its carbapenem-resistant strains are a growing concern. Comparatively, in Rwanda, Klebsiella also demonstrates antibiotic resistance but lacks the same widespread carbapenem resistance, highlighting variability in resistance patterns across regions [8]. Contributing factors, such as limited resources, poor infection control, and overuse of antibiotics, are consistent across African countries. However, resource constraints in facilities like CHUB exacerbate the issue, making it challenging to implement robust surveillance and control measures. Klebsiella pneumoniae is notorious for its ability to develop resistance mechanisms, such as ESBL production and carbapenem resistance. These traits significantly impact treatment options, leading to prolonged hospital stays and higher mortality rates, particularly in geriatric populations with compromised immunity. In elderly patients, Klebsiella infections are associated with severe outcomes, including sepsis and organ failure. The pathogen's capacity to form biofilms on medical devices (e.g., catheters and ventilators) further increases its impact on older, hospitalized patients. Across Africa, HAIs caused by Klebsiella impose a heavy burden on healthcare systems. Limited access to advanced diagnostics and second-line antibiotics exacerbates mortality rates compared to resource-rich settings [8].

Limitations of the Study

While our study provides valuable insights into the predictors of nosocomial infections among geriatric patients at CHUB, it is essential to acknowledge certain limitations. The cross-sectional design precludes the establishment of causal relationships between all risk factors and the occurrence of nosocomial infections. Additionally, the study was conducted at a single healthcare facility, potentially limiting the generalizability of the findings to other settings within Rwanda or beyond. The age targeted in the study design and population of 61 years and above was chosen because of correlation with the real demographic characteristics of patients received, rather the geriatric age in many other countries is >65 years and above.

Conclusions

The study highlights the heightened risk of nosocomial infections among geriatric patients, especially those over 61, at the University Teaching Hospital of Butare. Targeted prevention strategies addressing specific pathogens and risk factors like recent hospitalizations, hospital stay, WHO hand hygiene Five moments, disinfection of medical devices by Health Care providers, hands washing before taking medicines, having chronic conditions, and antibiotic use are crucial. Further research across multiple sites is needed to comprehensively understand and mitigate this burden on vulnerable elderly patients.

Based on the study findings at the University Teaching Hospital of Butare interventions should more specifically Klebsiella pneumoniae and ESBL-Producing Strains by enhanced surveillance systems, isolation protocols and biofilm disruption techniques to reduce colonization. The environmental decontamination and antibiotic rotation policies should be implemented to manage Acinetobacter spp. infections. As well hand hygiene adherence and preventive measures for urinary tract infections will address Escherichia Coli infections.

Efforts to mitigate the burden of nosocomial infections should prioritize the enhanced surveillance, establishing robust infection tracking systems across healthcare facilities, invest in antimicrobial stewardship and targeted interventions tailoring infection control practices to high-risk groups like geriatric patients.

REFERENCES

[1] J. S. Garner, W. R. Jarvis, T. G. Emori, T. C. Horan, and J. M. Hughes, "CDC definitions for nosocomial infections, 1988," *AJIC Am. J. Infect. Control*, vol. 16, no. 3, pp. 128–140, 1988, doi: 10.1016/0196-6553(88)90053-3.

[2] H. A. Khan, A. Ahmad, and R. Mehboob, "Nosocomial infections and their control strategies," *Asian Pac. J. Trop. Biomed.*, vol. 5, no. 7, pp. 509–514, 2015, doi: 10.1016/j.apjtb.2015.05.001.

[3] B. E. Ider, J. Adams, A. Morton, M. Whitby, and A. Clements, "Perceptions of healthcare professionals regarding the main challenges and barriers to effective hospital infection control in Mongolia: a qualitative study," *BMC Infect. Dis.*, vol. 12, 2012, doi: 10.1186/1471-2334-12-170.

[4] World Health Organization, "Report on the Burden of Endemic Health Care-Associated Infection Worldwide Clean Care is Safer Care," *World Heal. Organ.*, vol. 3, pp. 1–34, 2011.

[5] A. J. Kanouff, K. D. Dehaven, and P. D. Kaplan, "Prevention of nosocomial infections in the intensive care unit," *Crit. Care Nurs. Q.*, vol. 31, no. 4, pp. 302–308, 2008, doi: 10.1097/01.CNQ.0000336815.81676.88.

[6] S. M. Muturi *et al.*, "Recent Advances in Biological Research Vol. 3," *Recent Adv. Biol. Res. Vol. 3*, no. July, 2019, doi: 10.9734/bpi/rabr/v3.

[7] D. Mukamuhirwa *et al.*, "Prevalence of Surgical site Infection among Adult Patients at a Rural District Hospital in Southern Province, Rwanda," *Rwanda J. Med. Heal. Sci.*, vol. 5, no. 1, pp. 34–45, 2022, doi: 10.4314/rjmhs.v5i1.5.

[8] C. Bayingana, A. Sendegeya, F. Habarugira, C. Mukumpunga, F. Lyumugabe, and J. Ndoli, "Hospital Acquired Infections in Pediatrics Unit at Butare University Teaching Hospital (CHUB)," *Rwanda J. Med. Heal. Sci.*, vol. 2, no. 3, pp. 272–276, 2019, doi: 10.4314/rjmhs.v2i3.10.

[9] A. Umuhoza *et al.*, "The Risk of Neonatal Healthcare-Associated Infections at Three Teaching Hospitals in Rwanda," *Rwanda J. Med. Heal. Sci.*, vol. 6, no. 3, pp. 367–378, 2023, doi: 10.4314/rjmhs.v6i3.10.

[10] S. Lukas *et al.*, "Establishment of a hospital-acquired infection surveillance system in a teaching hospital in Rwanda," *Int. J. Infect. Control*, vol. 12, no. 3, pp. 1–9, 2016, doi: 10.3396/ijic.v12i3.018.16.

[11] V. Sanchini, R. Sala, and C. Gastmans, "The concept of vulnerability in aged care: a systematic review of argument-based ethics literature," *BMC Med. Ethics*, vol. 23, no. 1, pp. 1–20, 2022, doi: 10.1186/s12910-022-00819-3.

[12] United Nations Population Division, *World Population Ageing*. 2020. [Online]. Available: http://link.springer.com/chapter/10.1007/978-94-007-5204-7_6

[13] M. Esme, A. Topeli, B. B. Yavuz, and M. Akova, "Infections in the Elderly Critically-Ill Patients," *Front. Med.*, vol. 6, no. June, pp. 1–9, 2019, doi: 10.3389/fmed.2019.00118.

[14] M. Laurent *et al.*, "Impact of Comorbidities on Hospital-Acquired Infections in a Geriatric Rehabilitation Unit: Prospective Study of 252 Patients," *J. Am. Med. Dir. Assoc.*, vol. 13, no. 8, pp. 760.e7-760.e12, 2012, doi: 10.1016/j.jamda.2012.07.002.