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Nosocomial Infection Rates and Preventive Strategies in the Intensive Care Unit at Rwanda Military Hospital: A Retrospective Analysis

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ABSTRACT

Background*: Nosocomial infections, occurring > 48 hours after admission without evidence of pre-existing incubation, pose a significant challenge in intensive care units (ICUs), particularly for patients with prolonged hospital stays. In the 21st century, these infections affect approximately 10% of hospitalized patients, with higher rates observed in ICU settings. They contribute to extended hospitalization, disability, and economic burden. This study aims to evaluate the effectiveness of preventive measures in controlling nosocomial infections at Rwanda Military Hospital's ICU.*

Materials and Methods*: A retrospective cross-sectional study was performed on patients admitted to the ICU at Rwanda Military Hospital between January 2019 and December 2020. Data on nosocomial infections were retrieved from OpenClinic HMIS software, ICU registries, and patient files. Statistical analysis was performed using Microsoft Excel 21 and SPSS 21.*

Results*: Among 531 ICU admissions during the study period, 18% were identified with nosocomial infections. The infection rate was slightly higher in males (20%) compared to females (16.5%), with Enterobacteriaceae bacteria being the most common pathogens identified (35%).*

Conclusions*: Nosocomial infections remain prevalent in our ICU setting, highlighting the importance of adherence to infection prevention guidelines. Poor implementation of these guidelines emerges as a significant risk factor for nosocomial infections.*

Keywords: Nosocomial infection, Hospital-acquired infections, healthcare-associated infections, infection control, hand hygiene, multidrug resistance, antibiotic resistance, preventive guidelines

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1. Introduction

Despite the significant advancements in medical care, nosocomial infections (NIs) remain a critical challenge, particularly in Intensive Care Units (ICUs) where vulnerable patients are most at risk [1-4]. While global studies have highlighted the prevalence and impact of NIs [5,6], there is a noticeable gap in research specific to Rwanda, especially regarding the implementation of prevention and control measures in ICU settings. This gap underscores the need for focused research on the effectiveness of current infection control strategies in Rwanda's ICUs, specifically at Rwanda Military Hospital (RMH)-Kanombe.

Previous studies in Rwanda have reported varying rates of nosocomial infections across different departments and patient demographics [8-10]. However, these studies often lacked a comprehensive analysis of ICU-specific data, where the risk of NIs is significantly higher [7]. Moreover, the effectiveness of implemented prevention measures remains underexplored, with limited evidence on how well these guidelines are adhered to in practice. The challenge lies in understanding these measures' actual implementation and effectiveness in real-world settings, which past research has not adequately addressed [11-13].

The current study aims to fill this gap by assessing the prevalence of nosocomial infections in the ICU at Rwanda Military Hospital-Kanombe and evaluating the implementation of preventive measures. This study is crucial as it not only provides ICU-specific data but also offers insights into the effectiveness of current infection control strategies. By identifying gaps in implementing these measures, the study aims to contribute to developing more effective strategies tailored to the ICU environment. This research is particularly important as it addresses the urgent need to improve patient outcomes in critical care settings by reducing the incidence of nosocomial infections.

The primary objective of this study is to assess the prevalence of nosocomial infections in the ICU at Rwanda Military Hospital-Kanombe and to evaluate the adherence to and effectiveness of infection prevention and control measures. The study seeks to identify specific gaps in the implementation of these measures, providing actionable insights for enhancing patient safety and reducing the burden of nosocomial infections in ICUs.

2. Methods and Materials

Study design

To assess the implementation measures for preventing and controlling HAIs and identify gaps within these measures in the ICU at RMH, we used a retrospective study of all patients who were diagnosed with nosocomial infection due to their hospitalization in ICU department at RMH from 1st Jan 2019-31st Dec 2020.

Study Setting

The study was conducted in RMH in Nyarugunga Sector, Kicukiro District, and Kigali City. RMH is one of the four referral hospitals in Rwanda that serves the military and civilian population. It has different outpatient and inpatient departments, laboratory, medical and surgical departments, diagnostic imaging department and other support services. ICU is one of inpatient services and it can accommodate 12 beds.

Study Population

Our study included 531 patients admitted to ICU at RMH from January 2019- December 2020.

Inclusion and Exclusion Criteria

Inclusion criteria

All patients who were diagnosed with nosocomial infection due to their admission in ICU at RMH from 1st Jan 2019-31st Dec 2020 were included in this study.

Exclusion criteria

- Patients who already had an infection at the time of admission to the ICU.
- Patients who were admitted to the ICU with severe immunosuppression
- Patients who were admitted to ICU for less than 48 hours
- Patients who were transferred from other hospitals during the study time.

Data Collection

Data was collected through a questionnaire, utilizing the OpenClinic HMIS, ICU daybook, and patients' files. A Google Form questionnaire was distributed to assess ICU nurses' practices, with participation open during day working hours. Seven nurses, representing approximately one-third of the total nursing staff, responded to the questionnaire. The data collection occurred during daytime shifts, as the data collector was on duty during these hours.

Data Analysis

Data recorded and questionnaire were entered in a computer. The Statistical Package for Social Studies (SPSS version 21) was used to analyze data. Descriptive and inferential statistics 28 was used in the analysis of data. The margin of error was set at 0.05; thus, a p-value of less than 0.05 was considered significant.

Data Management

After data collection, questionnaires and checklists were stored in a locked cupboard with the key kept by the research team's leader. A strong password was used to secure the computer within which data had been collected. All soft and hard documents were kept confidential and used for the purpose of research only. These research documents will be kept confidential for five years and destroyed by shredding and incineration, while the soft copies will remain permanently stored in the e-archive.

Ethical consideration

- Participants were explained the purpose of this research and were handed a google-form document explaining in details the purpose of this research.
- Informed consent: After a thorough explanation of our research to the participants (ICU healthcare workers), they had right to sign the informed consent before participating in our research. No patient consent was required since the study was not directly involving patients.
- Confidentiality to protect the participants: No personal identification of the participants appeared into our questionnaire, only the initials were used instead. Also, to ensure the confidentiality of our participants, only initials were used on the checklist instead of personal identification. We kept the information on data collection sheet with the highest privacy and the information gathered was used for research purpose only.

3. Result

The cohort of patients admitted to the ICU at RMH-Kanombe between Jan-2019 and Dec-2020 consisted of 531 patients. Among these patients, 53.3% were males.

Most ICU admissions were middle-aged patients (54.2%, aged 30-60 years). Young patients accounted for 34.3%, while elderly patients made up 11.5% of the admissions. It was found that 18% had nosocomial infections, also known as health-acquired infections. Patients across

different age groups demonstrated similar probabilities (approximately 16%) of acquiring these infections (Table 1).

Gram data were collected from 98 patients who underwent culture. Of these, 54% were found to have gram-positive bacteria, while 46% had gram-negative bacteria.

Enterobacteriaceae was the most common pathogen, responsible for infections in 34.69% of the affected patients. This was followed by Coagulase-Negative Staphylococcus, which accounted for 15.31% of cases. Less prevalent infections, each contributing 1.02% to the total, including Aerobic and Anaerobic Cocci, Staphylococcus saprophyticus, Streptococcus viridans, Staphylococcus coagulase, and Klebsiella species (Table 2).

Ciprofloxacin was the primary treatment for the majority of patients (18%), followed by Imipenem (13%) and Vancomycin (10%) (Table 3). Out of the 30 sampled nurses, a significant majority (97%) demonstrated awareness of all necessary measures to prevent nosocomial infections. Additionally, an equal percentage of nurses (97%) confirmed their adherence to these established protocols.

The patient load assigned to a nurse during any given shift can constitute a potential risk factor for nosocomial infections. Nurses were surveyed regarding their perspectives on the manageable number of patients they could attend to individually during both day and night shifts. Findings (Figure 5) revealed that irrespective of the shift, there was only a 10% likelihood of a nurse caring for a single patient. On day shifts, there was a higher probability (67%) of a nurse attending to two patients. Additionally, there was a 23% chance of a nurse tending to three or more patients. Conversely, during night shifts, the patient load per nurse tended to increase. The data illustrated that 53% of nurses were responsible for caring for three or more patients (43% for a 1:3 ratio and 10% for a >1:3 ratio) during night shifts. This represents a 30% increase compared to day shifts (from 23% to 53%). Furthermore, the likelihood of a nurse caring for two patients during a night shift stood at 37%.

Table 1. Association between patients' characteristics and nosocomial infections in the ICU at Rwanda Military Hospital from January 2019 to December 2020. Study population: 531 patients

Characteristics	Yes	No	Total	Chi-Square	P-value
Gender	N (Percent)	N (Percent)			
Male	57 (20.1%)	226(79.9%)	283	1.144	0.285
Female	41(16.5%)	207(83.5%)	248		
Total	98(18.5%)	433(81.5%)	531		
Age	N (Percent)	N (Percent)			
18-39 years	30(16.5%)	152(83.5%)	182	1.185	0.553
40-59 years	58(20.1%)	230(79.9%)	288		
60 years and above	10(16.4%)	51(83.6%)	61		
Total	98(18.5%)	433(81.5%)	531		

Overall, the chi-square values are not statistically significant since their corresponding p-values are greater than the level of significance of 5%. For gender, the p-value is 0.285 whereas that of age is 0.553; all >0.05. Therefore, patients' characteristics had no significant effect of development of nosocomial infections.

Table 2. Types of Microorganisms Observed in the ICU at Rwanda Military Hospital from January 2019 to December 2020. Study population: 531 patients

Bacteria	Frequency	Percentage
Aerobes and anaerobes cocci	1	1.02
Bacilli	3	3.06
Coagulase negative	2	2.04
Coagulase negative cocci	2	2.04
Coagulase-negative staphylococcus	15	15.31
Cocci	5	5.10
Enterobacteriaceae	34	34.69
Grayish Colonies Cocci	1	1.02
Klebsiella species	1	1.02
Pseudomonas aeruginosa bacilli	3	3.06
Rods	6	6.12
Staphylococcus	2	2.04
Staphylococcus coagulase negative	3	3.06
Staphylococcus coccus	1	1.02
Staphylococcus aureus	14	14.29
Staphylococcus coagulase/Enterobacteriaceae	1	1.02
Staphylococcus saprophyticus	1	1.02
Staphylococcus coagulase	2	2.04
Streptococcus viridans	1	1.02

Table 3. Frequency of antibiotics prescribed to patients with NIs in the ICU at Rwanda Military Hospital from January 2019 to December 2020. Study population: 531 patients

Antibiogram	Frequency	Percent
Amikacin	4	4.9
Cefotaxime	4	4.9
Ceftazidime	1	1.2
Ceftriaxone	1	1.2
Ciprofloxacin	15	18.3
Clindamycin	7	8.5
Erythromycin	6	7.3
Gentamycin	7	8.5
Imipenem	11	13.4
Levofloxacin	3	3.7
Meropenem	5	6.1
Nitrofurantoin	3	3.7
Penicillin	1	1.2
Piperacillin	2	2.4
Tazobactam	1	1.2
Tetracycline	3	3.7
Vancomycin	8	9.8
Total	82	100.0

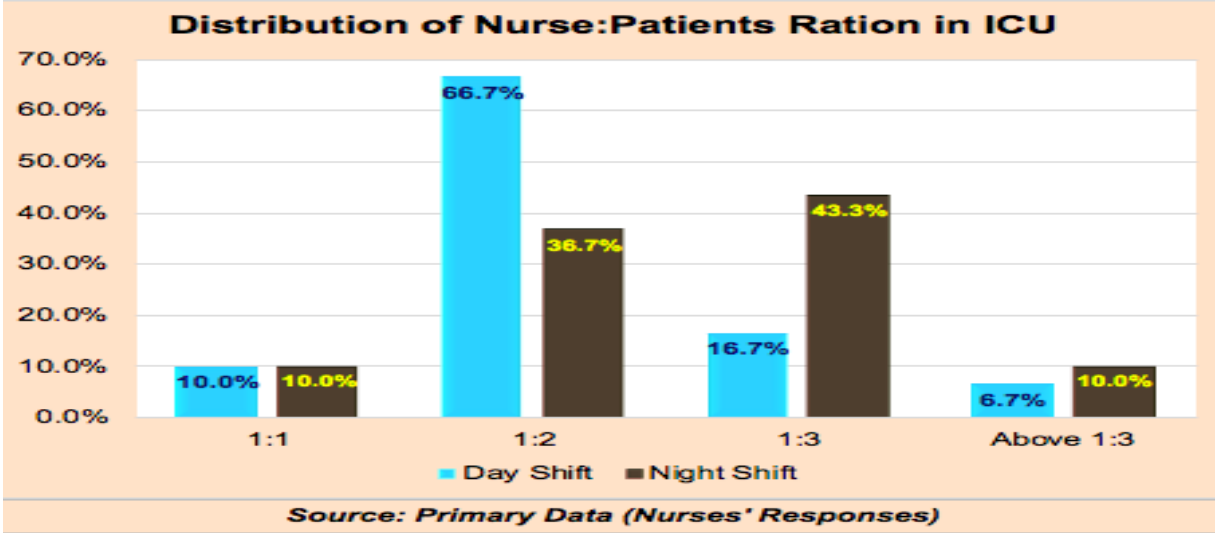

Fig 1. Nurse to Patients Ratio in the ICU at Rwanda Military Hospital from January 2019 to December 2020. Study population: 531 patients

Table 4. Implementation of NIs Prevention Measures in the ICU at Rwanda Military Hospital from January 2019 to December 2020. Study population: 531 patients

Measures	Yes	No	Total
	N(Percent)	N(Percent)	
Vaccinated for Covid-19 and Hepatitis B	30(100.0%)	0(0.0%)	30
Always wear protective wares in ICU like Gloves, surgical mask, protective eye shield, gown before touching a Patient	20(66.7%)	10(33.3%)	30
Always antiseptic wash hands before and after encountering each patient.	18(60.0%)	12(40.0%)	30
Presence of clear disposal system of waste materials in ICU	26(86.7%)	4(13.3%)	30
Always dispose waste materials where they should be	25(83.3%)	5(16.7%)	30
Always disinfect medical materials after its use	24(80.0%)	6(20.0%)	30
Presence of effective methods to sterilize and protect medical equipment in ICU	21(70.0%)	9(30.0%)	30
Timely and easy accessibility of materials to wash hands and disinfect hands to others.	27(90.0%)	3(10.0%)	30
Always do invasive catheterization in a sterile way	26(86.7%)	4(13.3%)	30
Routinely replace catheters within 48 hours if it was placed without aseptic technique.	8(26.7%)	22(73.3%)	30
Promptly remove a catheter that is no longer needed	20(66.7%)	10(33.3%)	30
Minimize sedation and length for intubation to minimize pooled secretions and elevate the bed 30 to 45 degrees	22(73.3%)	8(26.7%)	30
Always do oral care with either saline or antiseptic	8(26.7%)	22(73.3%)	30
Always give GI Ulcer prophylaxis to every patient to decrease ventilator associated pneumonia	21(70.0%)	9(30.0%)	30
Always have antiseptic to clean insertion site	15(50.0%)	15(50.0%)	30

Always avoid femoral veins when possible during central line insertion	22(73.3%)	8(26.7%)	30
Presence of efficient strategies to avoid to cross-contamination among patients	24(80.0%)	6(20.0%)	30
Always have appropriate diagnostic testing method when clinically indicated like: bottles for blood culture, materials for swabs, ...	22(73.3%)	8(26.7%)	30
Easy access of ICU patients to paramedical investigations like Chest X-rays, Ultrasounds, CT scan	24(80.0%)	6(20.0%)	30
Provision of prevention guidelines to patients in ICU	26(86.7%)	4(13.3%)	30
Change gown every time you finish patient care	12(40.0%)	18(60.0%)	30

Least Respected Measures:

Oral Care: Only 27% of respondents always do oral care with Chlorhexidine.

Catheter Replacement: 27% routinely replace catheters within 48 hours if placed without aseptic technique.

Protective Wares (Third Party): 40% ensure that every third party (caretakers, other department's healthcare providers) wears protective wares before entering the ICU.

Chlorhexidine for Insertion Site: 50% always have Chlorhexidine to clean the insertion site.

Moderately Respected Measures:

Protective Wares (ICU): 67% always wear protective wares like gloves, surgical masks, protective eye shields, and gowns before touching a patient in the ICU.

Hand Hygiene: 60% always wash hands before and after encountering each patient.

Catheter Removal: 67% promptly remove a catheter that is no longer needed.

Highly Respected Measures:

Vaccination: 100% of respondents are vaccinated for COVID-19 and Hepatitis B.

Waste Disposal System: 87% confirm the presence of a clear disposal system of waste materials in the ICU.

Disinfecting Medical Materials: 80% always disinfect medical materials after use.

Sterilization Methods: 70% acknowledge the presence of effective methods to sterilize and protect medical equipment in the ICU.

Hand Hygiene Accessibility: 90% report timely and easy accessibility of materials to wash and disinfect hands.

Catheterization Technique: 87% always perform catheterization in a sterile way.

Sedation and Intubation: 73% minimize sedation and intubation length to reduce pooled secretions and elevate the bed to 30 to 45 degrees.

Stress Prophylaxis: 70% always give stress prophylaxis to decrease ventilator-associated pneumonia.

Cross-Contamination Prevention: 80% report the presence of efficient strategies to avoid cross-contamination among patients.

Diagnostic Testing Accessibility: 73% confirm the availability of appropriate diagnostic testing methods when clinically indicated.

Paramedical Investigation Access: 80% report easy access for ICU patients to paramedical investigations like chest X-rays, ultrasounds, and CT scans.

Prevention Guidelines: 87% report that prevention guidelines are provided to patients in the ICU.

4. Discussion

This study revealed that 18% of patients admitted to the ICU at Rwanda Military Hospital (RMH) encountered at least one nosocomial infection, a figure that underscores the ongoing challenge of infection control in critical care environments. Notably, the study found no statistically significant association between demographic characteristics, such as age and gender, and the likelihood of developing a nosocomial infection. This finding contrasts with other research conducted in different settings in Rwanda where for instance one study highlighted that male patients had a significantly higher prevalence of nosocomial infections, indicating that gender might play a role in certain contexts [(17)].

The discrepancy in findings could be attributed to study design and population variations. Our study focused specifically on ICU patients, a cohort that is generally more vulnerable due to severe illness and invasive procedures, while other studies included a broader range of hospital patients. For example, a 2019 study in Rwanda at Centre Hospitalier Universitaire de Butare (CHUB) in the pediatric department, found a nosocomial infection prevalence of 12.1% among infants [(9)], a rate lower than that observed in our ICU-specific study. Similarly, a 2020 cohort study of 191 patients at a tertiary referral hospital in Rwanda reported a 32% prevalence of nosocomial infections across the entire hospital [(18)], which is notably higher than the 18% found in our ICU population. This disparity highlights how different patient populations and hospital departments can influence infection rates.

The variability in nosocomial infection rates across studies emphasizes the need for tailored infection prevention strategies. For instance, studies have shown that certain departments, like surgery, may have unique risk factors contributing to nosocomial infections. A study conducted in 2021 in two district hospitals in Rwanda reported an 11.7% prevalence of nosocomial infections [(17)], focusing mainly on patients in the surgical department. These findings, when compared to our study, suggest that specific hospital areas, such as ICUs, may require more rigorous and specialized infection control measures.

In addition to prevalence rates, the types of microorganisms associated with nosocomial infections also vary by region and hospital. Our study identified Enterobacteriaceae as the most prevalent microorganism in the ICU, accounting for 34.7% of infections. This contrasts with findings from a study at Kenyatta National Hospital in Kenya, where Pseudomonas aeruginosa, Klebsiella, Citrobacter, and Staphylococcus species were among the most frequently isolated pathogens. Particularly concerning is the high prevalence of Methicillin-Resistant Staphylococcus Aureus (MRSA) reported in 31.5% of cases in Mulago Hospital in Uganda [(19)]. This highlights the regional variations in pathogen prevalence and the importance of localized infection control protocols.

Despite the implementation of various infection prevention measures, our study found significant gaps in adherence to best practices. For instance, regular oral care with Chlorhexidine and the timely replacement of catheters placed without aseptic technique were poorly implemented, with only 27% adherence for each. Similarly, only

40% of respondents reported consistent use of protective wear by third parties entering the ICU. These lapses in protocol adherence suggest that while guidelines exist, their enforcement and routine practice may be lacking, thereby increasing the risk of nosocomial infections.

The literature underscores the importance of rigorous hygiene practices in reducing nosocomial infections. However, our findings reveal that even well-established measures are not universally respected. No single measure in our study achieved 100% compliance, indicating a significant need for improvement in hospital hygiene practices. Advocacy and training for healthcare workers, patients, and caregivers are crucial to enhancing adherence to infection prevention guidelines and ultimately reducing the prevalence of nosocomial infections.

The study underscores the complexity of nosocomial infection control, particularly in critical care settings like the ICU. While demographic factors may not significantly influence infection rates, the type of care setting, regional pathogen profiles, and adherence to hygiene protocols play a crucial role. Moving forward, hospitals must prioritize the consistent application of infection prevention measures across all departments to safeguard patient health and improve treatment outcomes.

Conclusion

The current study found that 18% of patients in the ICU at one institution experienced nosocomial infections. While demographic factors such as gender and age did not significantly influence the likelihood of infection, the study highlighted gaps in the implementation of preventive guidelines. The incomplete adherence to these guidelines could contribute to the continued presence and potentially rising rates of nosocomial infections. The study was conducted in a single institution, which may limit the generalizability of the findings to other settings. The study focused exclusively on ICU patients, potentially overlooking factors specific to other hospital departments that may influence nosocomial infection rates. The reliance on self-reported adherence to guidelines may have introduced bias, as actual practices could differ from what was reported. The study, on the other side, provides valuable insights into the prevalence of nosocomial infections in an ICU setting, where patients are at higher risk due to the nature of their conditions and treatments. It contributes to the limited body of research on nosocomial infections in Rwanda, offering a basis for comparison with similar studies in the region. Focusing on specific preventive measures allows for targeted recommendations to improve infection control practices.

Recommendation

- Healthcare providers should ensure strict adherence to all infection prevention guidelines, with particular emphasis on those measures identified as poorly implemented in this study.
- Ongoing training and education programs should be provided to healthcare workers to reinforce the importance of infection control practices.
- Further research should be conducted across multiple institutions and different hospital departments to gain a more comprehensive understanding of nosocomial infection patterns and contributing factors.
- Implementing routine audits and feedback mechanisms could help improve compliance with preventive guidelines and reduce the prevalence of nosocomial infections.

Abbreviation

%: Percentage
€: Euro currency
BUTH: Butare University Teaching Hospital
CAUTI: Catheter Associated Urinary Tract Infections
CDC: Centers for Disease Control and Prevention
CDI: Clostridioides Difficile Infection
CHUB: Centre Hospitalier Universitaire De Butare
CHUK: Centre Hospitalier Universitaire De Kigali
CLABSI: Central Line-Associated Bloodstream Infections
CMHS: College of Medicine and Health Science
CRBSI: Cather Related Bloodstream Infection
CSF: Cerebral Spinal Fluid
CVP: Central Venous Pressure
E.coli: Escherichia Coli
ECDC: European Centre for Disease Prevention and Control
ESBL: Extended Spectrum Beta-Lactamase
HAI: Health Care-Associated Infection
HAIS: Hospital Acquired Infections
HCPs: Health Care Providers
HCWS: Healthcare Workers
HMIS: Hospital Management Information System
HOD: Head of Department
ICU: Intensive Care Unit
IV: Intravenous Line
MRSA: Methicillin-Resistant Staphylococcus Aureus
NIS: Nosocomial Infections
Prof: Professor
RMA: Rwanda Military Academy
RDF: Rwanda Defense Force
RMA: Rwanda Military Academy
RMH: Rwanda Military Hospital
R-MPM: Rwanda Mortality Probability Model
SARS-COV-2: Severe Acute Respiratory Syndrome Coronavirus 2
SPSS: Statistical Package for Social Studies
SSI: Surgical Site Infections
UR: University Rwanda
USAID: United States Agency for International Development
UTIS: Urinary Tract Infections
VAP: Ventilator Aspiration Pneumonia
VRE: Vancomycin Resistant Enterococci
WHO: World Health Organization

Author Contributions

All authors conceived and designed the study. Sacré Mubasha carried out the literature review and wrote the manuscript, Hubert Mucyo analyzed the data, and Fabrice Twahirwa participated in the discussion. All authors contributed to manuscript revisions. All authors approved the final version of the manuscript and agreed to make Christian Mukwesi the corresponding author.

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Conflict of Interest

The authors declare that they have no competing interest.

Ethical approval

An ethical approval was obtained from CMHS and RMH research committee.

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