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INYUVESI YAKWAZULU-NATALI

IMPACT OF AN INFECTIOUS DISEASE TRAINING MODULE ON THE AWARENESS REGARDING ANTIMICROBIAL STEWARDSHIP, INFECTION PREVENTION AND CONTROL PRACTICES AMONG THIRD-YEAR MEDICAL STUDENTS IN KWAZULU-NATAL

BY

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School of Laboratory Medicine and Medical Sciences

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PREFACE

This study represents original work by the author and has not been submitted in any other form to another University. Where use was made of work of others, it has been duly acknowledged in the text.

The research described in this dissertation was carried out in the Department of Microbiology, School of Laboratory Medicine and Health Sciences, University of KwaZulu Natal, South Africa, under the supervision of Prof. K. Swe Swe-Han and co-supervision of Dr Reina Mary Abraham.

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Prof. K Swe Swe-Han
Supervisor

Dr Reina Mary Abraham
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DECLARATION

I, Dr Asmeeta Burra (student number: 933481203), declare as follows:

1. The research reported in this dissertation, except where otherwise indicated, is my original work.
2. That the work described in this dissertation has not been submitted to UKZN or any other institution for the purposes of an academic qualification, whether by myself or any other party.
3. This dissertation does not contain other persons' data, pictures, graphs or other information unless specifically acknowledged as being sourced from other persons.
4. That my contribution to the project was the role of the primary researcher. The role encompassed project conceptualization, methodology and protocol development and applications for ethical clearance and relevant consents. Data curation, formal data analysis and completion of the final written dissertation were also the responsibility of the primary author.
5. The contributions of others to the project include those of Prof. Khine Swe Swe-Han (National Health Laboratory Service and Department of Medical Microbiology at the University of KwaZulu-Natal) and Dr Reina Mary Abraham (Department of Clinical Skills, Clinical and Professional Practice, Nelson R. Mandela School of Medicine, University of KwaZulu Natal). Prof. K. Swe Swe-Han's contribution encompassed the role of project supervisor, which included synthesis of the protocol and editing and review of the dissertation as well as assessment of MMED progress as Head of Department. Dr Reina Mary Abraham encompassed the role of project co-supervisor, who reviewed and extensively edited the protocol and manuscript within the dissertation for publication.

Signed:  Date: /03/2025

Asmeeta Burra

DEDICATION

I dedicate this thesis to my family.

Thank you for your unconditional love, support and encouragement.

ACKNOWLEDGEMENTS

- First, I would like to thank God for granting me the opportunity to complete this dissertation.
- My deepest gratitude to my supervisor, Prof. Khine Swe Swe-Han, for believing in me throughout my Microbiology journey. This endeavour would not have been possible without your motivations to UKZN, NHLS and CMSA. Your unwavering support to see me succeed is deeply appreciated. I thank you for your invaluable encouragement and mentorship.
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- I am also thankful to the Nelson R Mandela School of Medicine at the University of KwaZulu-Natal for allowing me permission to engage with the third-year medical students. A special thanks to the students who so willingly shared their thoughts and whose answers and responses have contributed to the data of the study.
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SUPERVISORS

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LIST OF ABBREVIATIONS

AMR – antimicrobial resistance

AMS – antimicrobial stewardship

CDC - Center for Disease Control and Prevention

MDR - multi-drug resistant

IPC - infection prevention and control

HCAI – healthcare-associated infection

HCW – healthcare worker

UKZN – University of KwaZulu-Natal

WHO – World Health Organization

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CHAPTER 1

INTRODUCTION

1.1 Background

Antimicrobial resistance (AMR) occurs when microorganisms such as bacteria, viruses, fungi, and parasites become resistant to antimicrobial drugs, rendering treatments ineffective and increasing the risk of disease spread, severe illness, and death (World Health Organisation [WHO],2024). Infections with AMR organisms are also associated with increased length of hospital stay and higher management costs. The WHO has justifiably raised concern regarding the global spread of "superbugs" or multi- and pan-resistant bacteria against which existing antimicrobials are ineffective (WHO,2024). Given the numerous challenges associated with Multi-drug resistant MDR organisms, they have declared that AMR is one of the top 10 global public health threats facing humanity (WHO,n.d.).

AMR is a complex concept and antimicrobial stewardship forms a foundational step in curbing the development of AMR. Antimicrobial stewardship (AMS) refers to coordinated interventions designed to improve and measure the appropriate use of antimicrobials by promoting the selection of the optimal antimicrobial drug regimen, dose, duration of therapy, and route of administration (Fishman N., 2012). Foundational AMS knowledge and practice are critical to preventing the development of AMR.

Notably, most infections with resistant pathogens are acquired in hospitals i.e. they are nosocomial or Healthcare-associated Infections (HCAI). A healthcare-associated infection is defined as "An infection occurring in a patient during care in a hospital or other healthcare facility, which was not present or incubating at the time of admission." (WHO, 2010). These are usually acquired after hospitalisation and manifest 48 hours after admission to the hospital. Importantly, these infections are preventable with infection prevention and control (IPC) measures. IPC comprises evidence-based practices designed to prevent the transmission of infections in healthcare settings (WHO,n.d.). AMR and IPC are therefore integrally interlinked.

To address the issue, the World Health Assembly adopted a global action plan on antimicrobial resistance in May 2015. The plan encompasses five key objectives: raising

awareness and knowledge about AMR through education, optimising the use of antimicrobials, promoting IPC to reduce infection rates, conducting surveillance and research, and increasing investment in new medicines and interventions (WHO,2015).

WHO's "Patient Safety Curriculum Guide for Medical Schools" advocates for a shift in medical education from focusing solely on disease management to incorporating prevention strategies in undergraduate training (WHO, 2009). Integrating comprehensive training on AMR, AMS and IPC into medical curricula is crucial to equipping future healthcare professionals with the necessary knowledge and skills to counter these problems.

The pre-clinical undergraduate years are the optimal time to introduce these concepts. We must enforce the foundational knowledge for good practice and inculcate correct practice behaviours early on. Given the complexity of the concepts, teaching should be ongoing with regular assessment of teaching outcomes. Any gaps in knowledge must be identified so that the curriculum can be updated to address these gaps.

At UKZN, we are cognizant of the global threat of AMR and the need for action by optimising our undergraduate training. There is little known research on our student's competencies regarding AMR, AMS and IPC.
This warranted a baseline assessment of the University of KwaZulu Natal's 3rd-year pre-clinical students' perceptions and knowledge of AMR and IPC so that any gaps could be identified and prioritized for redress.

1.2. Literature Review

Antimicrobial Resistance (AMR)

According to the Center for Disease Control and Prevention (CDC), resistant organisms pose a significant public health threat (CDC, 2019). They define an antimicrobial as "A

substance, such as antimicrobial agents, that kills or stops the growth of microbes, including bacteria, fungi, or viruses"(CDC,2019).
When antimicrobials become ineffective, infections become difficult to treat or may not be treatable at all (WHO,2024), with resultant increased morbidity and mortality, increased length of hospital stay, increased need for intensive care and increased cost. Hence, resistant organisms pose a significant public health threat (CDC,2024). According to WHO, even elective procedures such as caesarean sections, transplant surgery and chemotherapy will become more risk-laden (WHO,n.d.).

Compounding these concerns is the limited development of new, effective antimicrobials (WHO,n.d.) and the limited availability of vaccines against the leading drug-resistant pathogens (Murray et al, 2019).

On a positive note, the implementation and ongoing enforcement of IPC measures can contain and limit the spread of AMR organisms.

Healthcare-associated Infections and Infection Prevention and Control

Prior research has shown that medical students are exposed to infectious diseases as an occupational hazard (Ibrahim et al., 2016) and that they also serve as a vector for the spread of resistant organisms (Chauhan, 2017).

Keicher et al.(2024), underlined the significant risk healthcare workers are exposed to following needlestick injuries, with possible transmission of pathogens such as human immunodeficiency virus, hepatitis C virus and hepatitis B. They noted the underreporting of these injuries among medical students and remarked that this is possibly due to a lack of awareness and knowledge. They consequently suggested addressing this in the medical curriculum.

In relation to the concern for needlestick injuries, The Department of Health recommends that all healthcare workers (HCWs) should be vaccinated against Hepatitis B. (RSA DOH, 2020). A study by Makan(2023) at the University of Witwatersrand, found a gap in the

completion of a full three-dose vaccination series among health science students. Makan recommended improved education and awareness to encourage health-seeking behaviour and advocacy among students. Thus, fostering awareness is a key component in promoting IPC measures.

Several studies have highlighted that strict compliance with simple infection control measures such as standard precautions, can prevent the spread of pathogens (Goyal et al., 2019; Ibrahim et al., 2016), thereby protecting patients, visitors and healthcare workers. The "WHO Patient Safety Curriculum Guide for Medical Schools" (2009) refers to a new science of "patient safety". The WHO curriculum guide highlights that "harm to patients is not inevitable and can be avoided".

This underlines the need for medical students to enter their clinical years with an awareness and adequate knowledge of the basic principles of IPC. A basic understanding of routes of infection, standard, contact and droplet precautions, is vital prior to interacting with patients.

Additionally, prior research has found that medical students are inadequately prepared to enter their clinical years. A study by Ibrahim et al. (2016) in Qatar found that medical students' knowledge of IPC was inadequate. In their study, Goyal et al. (2019) concluded that there is non-compliance to basic IPC measures such as hand washing among healthcare workers. Both studies have suggested early inclusion of this training in the undergraduate medical programme. Furthermore, regular training and reinforcement of knowledge is advocated.

As the doctors of tomorrow, medical students need foundational knowledge and awareness to facilitate insight into the consequences of inadequate IPC practice. This will deepen their understanding of the responsibility they hold and motivate them to take accountability for their own and their patient's safety.

Antimicrobial stewardship

WHO defines antimicrobial stewardship as "a coherent set of actions which promote the responsible use of antimicrobials" (WHO,2019). Very few new antibiotics are being developed. Suboptimal prescribing practices have been linked to the development of AMR (Wasserman et al., 2017). We therefore need to optimize the use of existing antibiotics to prevent the development of resistance and extend their lifespan of effectiveness. This is totally dependent on the adoption of correct AMS prescribing behaviours (WHO, 2019).

Of concern is the widespread use of antimicrobials, with prescriptions written by interns, junior doctors and doctors across a spectrum of disciplines. Studies highlight that the level of training regarding the correct use of antibiotics varies widely, and only select patient cases are referred to infectious disease specialists (Abbo et al., 2013). This is corroborated by a study by Wasserman et al. (2017), which showed that only 33% of medical students in South Africa feel confident with regard to prescribing antimicrobials.

A study by Yuste et al. (2022) states that antibiotic prescriptions can be further optimised in 30-50 percent of cases. They highlight that doctors with less training with regard to antibiotic prescribing tend to use more broad-spectrum agents. Common errors in prescribing include incorrect duration of therapy, omitting to de-escalate from a broad spectrum to a narrow spectrum antimicrobial, or switching from intravenous to the oral route of administration, treating non-infectious syndromes with antimicrobials, and treating colonisation or contamination (Yuste et al., 2022).

Several studies have highlighted the importance of the implementation of comprehensive medical school curricula regarding AMS.

Abbo et al.(2013), recommended that antimicrobial stewardship be taught during medical school. Wasserman et al. (2017) concluded that medical students may be inadequately educated regarding the prescribing of antimicrobials during their undergraduate years and may not fully appreciate the consequences of AMR. Their study showed that 95% of

students would like more training on antibiotics, which bodes well for prospective curriculum development. Aboo et al.(2013) also confirm that medical students are willing to receive more training in these fields.

Abbo et al.(2013) highlighted the need to assess the curricula and teaching pedagogy regarding antimicrobial stewardship. Wasserman et al. (2017), found that there are differences in curriculum content across South African universities, with no standardisation of teaching content. It was therefore imperative that we assessed our students' knowledge and awareness regarding this concept.

Considering the above, it is evident that the foundation for good medical practice needs to be laid during the pre-clinical years. Are our pre-clinical students adequately prepared to transition from the preclinical to clinical years in the wards where they will interact with patients, pathogens and antimicrobials?

1.3 Aims and Objectives

Our study aimed to access the attitudes, perceptions and knowledge of preclinical medical students regarding infection prevention and control and the spread of antimicrobial-resistant organisms.

The specific objectives of this research were:

1. To assess knowledge and awareness of antimicrobial resistance, stewardship and infection prevention and control in medical students in UKZN using a standard question set up.

2. To evaluate the impact of infectious disease training in eliminating any existing gaps in knowledge and awareness of antimicrobial resistance and infection prevention and control.

1.4 Research Questions

What are the third-year medical students' perceptions and attitudes regarding antimicrobial resistance, antimicrobial stewardship and infection prevention and control?

What are the third-year medical students' knowledge of antimicrobial resistance, antimicrobial stewardship and infection prevention and control?

What was the impact of an infectious disease training module on the awareness of third-year medical students regarding antimicrobial resistance, antimicrobial stewardship and infection prevention and control? Are there any gaps that need to be addressed?

Inclusion criteria

All consenting registered Year 3 Medical students in UKZN during 2023 who attended the Infectious Disease Module.

Exclusion criteria

Students who were not in their third year of study or had not registered or attended the Infectious Disease Module were excluded from the study.

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CHAPTER 2

IMPACT OF AN INFECTIOUS DISEASE TRAINING MODULE ON THE AWARENESS REGARDING ANTIMICROBIAL STEWARDSHIP, INFECTION PREVENTION AND CONTROL PRACTICES AMONG THIRD-YEAR MEDICAL STUDENTS IN KWAZULU-NATAL

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IMPACT OF AN INFECTIOUS DISEASE TRAINING MODULE ON THE AWARENESS REGARDING ANTIMICROBIAL STEWARDSHIP, INFECTION PREVENTION AND CONTROL PRACTICES AMONG THIRD-YEAR MEDICAL STUDENTS IN KWAZULU-NATAL

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ABSTRACT:

Background

Antimicrobial resistance (AMR) is a global health threat, driven by inappropriate antimicrobial use and inadequate infection prevention and control (IPC). Medical students play a key role in future antimicrobial stewardship (AMS) and IPC efforts, making early education essential. Studies highlight knowledge gaps in these areas, emphasizing the need for structured interventions. This study evaluates the impact of an infectious disease module on third-year medical students' knowledge, attitudes, and perceptions of AMR, AMS, and IPC at the University of KwaZulu-Natal (UKZN).

Objectives:

To assess baseline knowledge, attitudes, and perceptions of AMR, AMS, and IPC among third-year medical students and evaluate the module's effectiveness in improving these domains.

Methods:

A cross-sectional mixed-methods study was conducted among third year class of 240 medical students using pre- and post-module four-week multidisciplinary Infectious Disease module questionnaires. Likert-scale and knowledge-based questions assessed knowledge, attitudes, and perceptions. Quantitative data were analysed using descriptive and inferential statistics, and qualitative responses underwent thematic analysis.

Results:

A total of 88 students completed the pre-module (36.7%) and 210 the post-module (87.5%) assessments. Baseline attitudes and perceptions (71.8%) were higher than knowledge scores (62%). Post-module, knowledge improved by 12.2%, and attitudes/perceptions by 11.1% ($p<0.001$). IPC knowledge was higher at baseline, likely due to COVID-19 awareness. Persistent misconceptions in AMS highlight the need for reinforcement.

Conclusion:

The module significantly improved knowledge, attitudes, and perceptions. However, AMS gaps remain, necessitating ongoing education. Standardized curricula incorporating case-based learning and clinical exposure are recommended. Future studies should assess long-term knowledge retention and clinical impact.

Key words: infectious disease module, antimicrobial stewardship, infection prevention and control practices, third-year medical students, pre- and post-assessment

2.1 Introduction

Antimicrobial resistance (AMR) occurs when microorganisms such as bacteria, viruses, fungi, and parasites become resistant to antimicrobial drugs, rendering treatments ineffective and increasing the risk of disease spread, severe illness, and death.[1] The growing prevalence of multidrug-resistant organisms, or "superbugs," has become a global health concern due to the ineffectiveness of existing antimicrobials against these pathogens.[1] The World Health Organization (WHO) has identified AMR as one of the top ten global public health threats.[1] WHO defines a healthcare-associated infection (HCAI) as "An infection occurring in a patient during care in a hospital or other healthcare facility, which was not present or incubating at the time of admission." [2] These are usually acquired after hospitalisation and manifest 48 hours after admission to the hospital. Many resistant bacteria causing infections are nosocomial or HCAIs and are preventable with infection prevention and control (IPC) measures. IPC comprises evidence-based practices designed to prevent the transmission of infections in healthcare settings.[3]

The WHO's 2015 Global Action Plan on AMR emphasizes five key strategies: raising awareness, optimizing antimicrobial use, promoting IPC, enhancing surveillance and research, and increasing investment in new medicines.[4] Given the complexity of AMR, integrating AMR and IPC education into medical curricula is crucial to equipping future healthcare professionals with the necessary knowledge and skills.

WHO's "Patient Safety Curriculum Guide for Medical Schools" advocates for a shift in medical education from focusing solely on disease management to incorporating prevention strategies in undergraduate training.[5] Consequently, medical schools should include robust training on patient safety, AMR, and IPC within their curricula. Medical students are at risk of occupational exposure to infectious diseases and may inadvertently contribute to the spread of resistant organisms if IPC principles are not adequately

reinforced.[6,7] Studies have shown that medical students often have inadequate IPC knowledge[6] and poor compliance with IPC measures, such as hand hygiene. [9]. These findings highlight the importance of structured IPC training early in medical education.

The need for training on antimicrobial prescribing is equally important. Antimicrobial stewardship (AMS) refers to coordinated interventions designed to improve and measure the appropriate use of antimicrobials by promoting the selection of the optimal antimicrobial drug regimen, dose, duration of therapy, and route of administration.[10] Abbo et al.[11] reported significant variability in the level of training on antimicrobial use across different medical schools and noted that only select patient cases are referred to infectious disease specialists. Similarly, a study in South Africa found that only 33% of medical students felt confident about prescribing antimicrobials,[8] yet interns and junior doctors frequently prescribe these medications. Encouragingly, 95% of students expressed a desire for more training in antibiotic use.[8] Abbo et al.[11] highlighted that there is a need to assess the curricula and teaching pedagogy regarding AMS of a system for educating and supporting healthcare professionals to use antimicrobials responsibly. Wasserman et al.[8] and Yuste et al.[12] underscored the importance of standardised curricula and continuous AMS training to ensure knowledge retention and responsible prescribing practices.[11,12]

Assessing the current curricula and teaching approaches is crucial to identify gaps and implement evidence-based guidelines. Given the variations in AMR, AMS, and IPC training across South African universities, there is a need to assess the current curriculum at the University of KwaZulu-Natal (UKZN). This study aims to evaluate the attitudes, perceptions, and knowledge of third-year medical students regarding AMR, AMS, and IPC. Identifying gaps will help inform curriculum improvements to better prepare students for clinical practice, where they will interact with patients, pathogens, and antimicrobials in real-world settings.

2.2 Methods

Context and setting

The study was conducted within the undergraduate medical programme at the Nelson R Mandela School of Medicine, University of KwaZulu-Natal. This six-year programme consists of three pre-clinical years, followed by three years of clinical training. The study targeted third-year students enrolled in a four-week multidisciplinary "Infectious Disease" module which covers key concepts in infectious diseases, including concepts in microbiology, virology, pharmacology, molecular biology, haematology, infectious diseases and ethics, with a focus on IPC, AMR, and AMS. A detailed list of teaching topics is provided in Annexure 1.

Study design

A cross-sectional mixed methods study design was conducted to assess the impact of the Infectious Disease module on students' knowledge, perceptions, and attitudes regarding IPC, AMS and AMR. Both quantitative and qualitative data were collected. The study aimed to recruit all third-year students of 240 students in the 2023 academic year.

Study Participants

Students were recruited at the start of the module during an introductory lecture and again after the end of module examination. All registered third-year medical students attending the module were eligible. Those not in their third year or not registered were excluded. Participants were informed about the study objectives, and informed consent was obtained. Participation was voluntary, and students received a chocolate as a token of appreciation.

Intervention

The intervention was the four-week Infectious Disease module, which was structured to include interactive lectures, practical sessions, and case discussions focusing on key topics related to infectious disease control covering principles of IPC, AMR, and rationale for antimicrobial use.

Data collection Instrument

A structured questionnaire, adapted from WHO and CDC guidelines on IPC and AMR, and validated instruments (Ibrahim et al., 2016; Wasserman et al., 2017; Goyal et al., 2019; Tavolacci et al., 2008; Chauhan, 2017; Nowbath et al., 2023) was used for data collection.

The questionnaire included seven sections:

Section A. Demographic data

Section B. Perceptions and Attitudes regarding AMR and AMS

Section C. Attitudes and perceptions regarding IPC

Section D. Knowledge of AMR and AMS

Section E. Knowledge regarding IPC

Section F. Open-ended questions to gather student feedback (pre-module), with additional post-module open-ended questions to assess student's perceptions of the module's educational quality and areas for improvement.

Students completed the questionnaire before and after the module. Sections A to F were included in both the pre- and post-module questionnaires, with additional post-module questions in section F.

Responses in sections B and C, were recorded using a three-point Likert scale, (agree/disagree/unsure), while sections D and E, used "true/false/unsure" knowledge-based questions. Correct answers were assigned a value of 1, while incorrect and "unsure" responses were scored 0.

Ethical Considerations

Ethical approval was obtained from the Humanities and Social Sciences Research Ethics Committee, University of KwaZulu-Natal (HSSREC/00006160/2023). Gatekeeper approval was secured from the University Registrar. All participants provided written informed consent.

2.3 Data analysis

Quantitative data were analysed using descriptive and inferential statistics. Means, medians, and interquartile ranges were calculated. The paired t-test was used to compare pre- and post-module scores for normally distributed data, while the Wilcoxon rank-sum test was applied for non-normally distributed data. A p-value of <0.001 was considered statistically significant.

The percentage of correct responses per question was calculated, and pre-and post-module differences were reported. Additionally, responses were stratified by gender and whether the students were first- or second-degree learners.

Qualitative responses to the open-ended questions were thematically analysed, coded and categorized into themes to provide insights into students' experiences and perceptions. Data triangulation was employed by merging the quantitative and qualitative findings for a comprehensive evaluation of the module/educational intervention's impact.

Tables and figures illustrating and summarizing key findings are presented in the results section.

2.4 Results

Demographics

A total of 88 students (36,7%) completed the pre-module questionnaire, while 210 (87,5%) responded post-module, including some incomplete questionnaires. Hence responses for some sections are below total number of responses of 210. Most respondents were female (69.3% [61/88] pre-module, 61.7%[129/209] post-module) and aged between 18 and 25 years (89.8%[79/88]pre-module, 96.2%[201/209] post-module). Most students were studying medicine as their first degree (84.1% [74/88] pre-module, 88.0% [184/209] post-module).

Overall scores

Total pre- and post-module scores for all domains assessed are shown in Table 1. The scores in the two sections regarding the "attitudes and perceptions" to AMR, AMS and IPC were combined (survey sections B&C), and the two sections on "knowledge" of AMR, AMS and IPC were combined (survey sections D&E) and analyzed separately. A two-sample Wilcoxon rank-sum test was used to compare the total pre- and post-module scores. Total improvement was statistically significant with $p < 0{,}001$. This improvement was reflected in students' feedback. Pre-module comments included *'I feel that my knowledge surrounding these topics are very limited*", '*The quiz has shown me that I need more training and preparation* …' whilst post-module a student commented: '*I do feel more prepared than I was before doing this module*'.

Table 1: Comparison of pre-and post-module responses; Total score across all sections, Total Attitudes and perceptions on AMR, AMS &IPC and Total Knowledge on AMR, AMS & IPC

Total score across all sections							
Group	**n**	**median**	**IQR**		**min**	**max**	**Wilcoxon test**
Pre-module	88	66,4%	58,9%	72,1%	40,9%	89,8%	< 0.001
Post-module	207	78,9%	69,5%	85,4%	15,4%	95,1%	
Total Attitude and Perceptions on AMR, AMS & IPC (Total n=295)							
Group	**n**	**median**	**IQR**		**min**	**max**	
Pre-module	88	71,8%	59,6%	79,5%	37,6%	93,4%	< 0.001
Post-module	207	82,9%	75,6%	90,6%	16,0%	100,0%	
Total Knowledge on AMR, AMS & IPC (Total n =295)							
Group	**n**	**median**	**IQR**		**min**	**max**	
Pre-module	88	62,0%	54,0%	68,2%	33,8%	89,1%	< 0.001
Post-module	207	74,2%	64,4%	81,9%	10,9%	94,0%	

Pre-module, students scored higher on attitudes and perceptions of AMR, AMS & IPC (median 71,8%), compared to knowledge of AMR, AMS & IPC (median 62%). Table 1 illustrates post-module improvements in both categories, with knowledge scores increasing by 12.2% and perceptions and attitudes scores by 11.1%.

All sub-sections showed significant improvements (p<0,001).

Perceptions and Attitudes Towards AMR and AMS

The total scores for participants' pre- and post-module response scores on perceptions and attitudes toward AMR and AMS are presented in Table 2.

Table 2: Pre- and Post-Module Responses on Perceptions and Attitudes on AMR and AMS

Group	n	median	IQR		Min	Max	p value
Pre-module	88	66,7%	55,6%	77,8%	44,4%	100,0%	<
Post-module	207	83,3%	72,2%	88,9%	0,0%	100,0%	0.001

The median score improved from 66,7% pre-module to 83,3% post-module with a statistically significant p-value of <0,001, indicating a positive impact of the module on participants' perceptions and attitudes on AMR and AMS-related concepts.

Figure 1 provides a detailed breakdown of responses to individual questions, with most items showing notable improvements in awareness and understanding of AMR-related concepts.

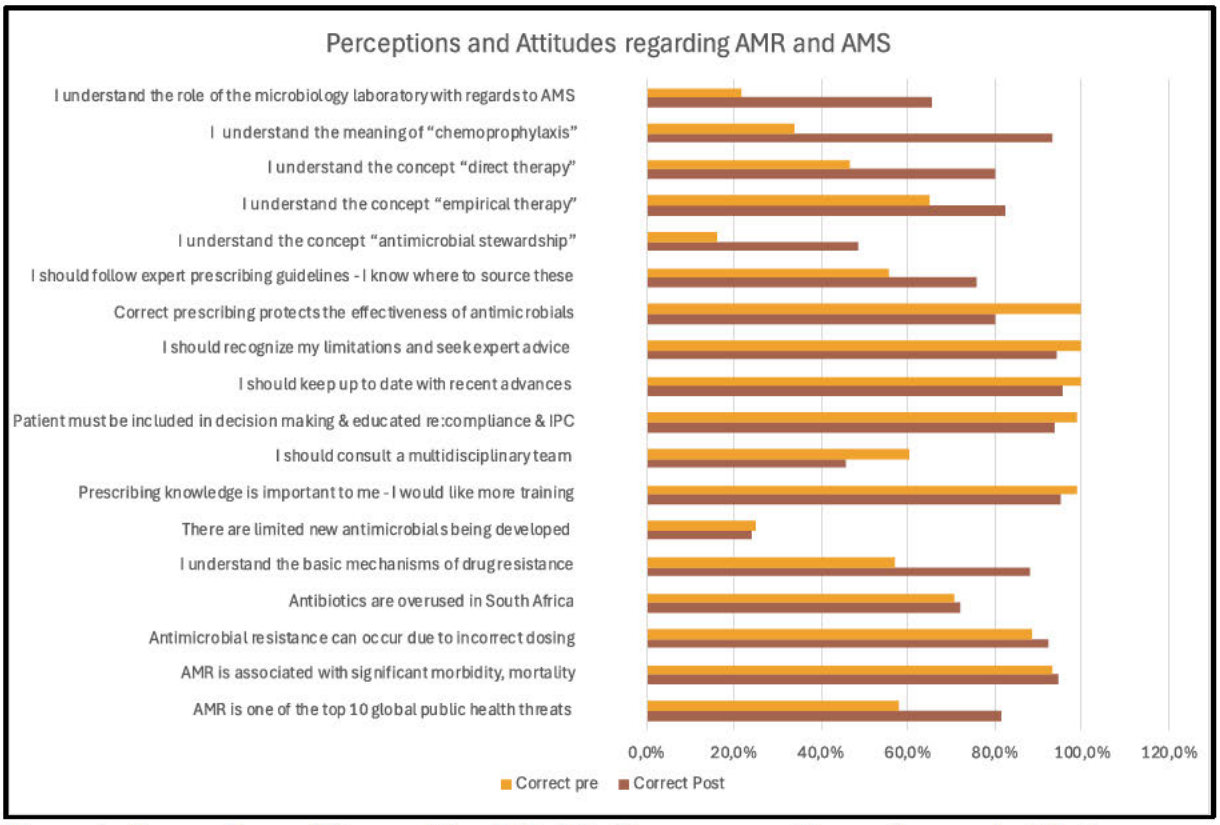

Figure 1: Comparison of Pre- and Post-Module Responses on Perceptions and attitudes towards AMR and AMS concepts

Pre-module 58% of participants recognized AMR as a top public health threat, and 25% acknowledged the limited development of new antimicrobials. (Figure 1)

Understanding of the AMS concept was initially low (15.9%) but increased to 48,3% post-module. Participants expressed their need for further knowledge with comments such as "*I still need more knowledge on antimicrobial stewardship"* and *"I understand the basics, but I don't feel fully comfortable with AMR*".

The pre-module understanding of the microbiology lab's role in relation to AMS was 21.6%, which improved to 65.2% post-module.

Regarding antibiotic prescribing practices, the following observations were noted: pre-module 70,5% agreed that antibiotics are overused in South Africa. Pre-module understanding of key prescribing concepts was low with 46,6% understanding "direct therapy", 34,1% understanding "chemoprophylaxis", and 98,9% acknowledging the need for additional training on antimicrobial use.

Post-module responses demonstrated improvements across these areas with a student commenting: '*The lectures provided have helped me gain insight with regards to prescription and antibiotics*' and '*... the importance of AMR was emphasised enough'.*

Finally, in the domain of decision-making and continuous learning, all participants (100%) agreed on the importance of seeking expert advice and staying informed about recent advances in AMR and AMS. This was evidenced by a student stating, '*I also have readily available resources and peers and doctors that I may consult with'.*

Attitudes and perceptions regarding IPC

Pre-module participants' median scores for attitudes and perceptions regarding IPC (76,9%) as illustrated in Table 3, were higher compared to their perceptions and attitudes regarding AMR and AMS (66,7%).

Following the module, the median IPC score increased significantly to 84.6% ($p < 0.001$), reflecting improved awareness and attitudes towards infection prevention and control.

Table 3: Pre- and Post-Module Responses on Attitudes and Perceptions regarding IPC

Group	**n**	**median**	**IQR**		**Min**	**Max**	p value
Pre-module	88	76,9%	61,5%	84,6%	23,1%	100%	< 0.001
Post-module	207	84,6%	76,9%	92,3%	0,0%	100%	

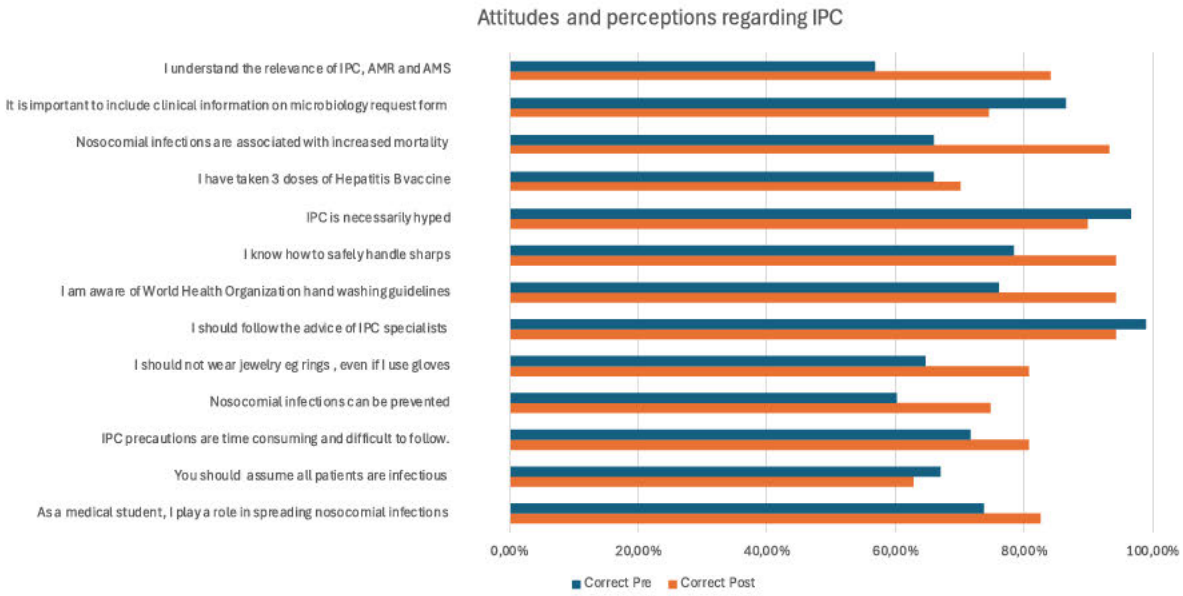

Figure 2: Comparison of Pre- and Post- Post-module Responses on Attitudes and Perceptions regarding IPC concepts

As illustrated in Figure 2, before the module, only 56,8% of participants agreed that they understood the relevance of IPC, AMR and AMS. This figure improved to 84,1% post-module, reflecting improved awareness.

A review of pre-module attitudes towards professional responsibility in IPC revealed that 73,86% agreed that as medical students, they have a role to play in spreading nosocomial infections and 60,2 % agreed that nosocomial infections are avoidable. These scores improved after the module demonstrating an improved understanding as evidenced by one student's comment: '*I am now more aware of my role in nosocomial infections*'.

Regarding compliance and barriers to IPC practice, the module identified key areas for improvement as 35% of students could not confirm completing a series of hepatitis B vaccines and 35% considered it acceptable to wear jewellery at work e.g. rings if they wore gloves over.

In terms of knowledge and awareness of IPC guidelines, 78,4% of participants felt confident to safely handle sharps pre-module, which increased to 94,2% post-module.

Awareness of WHO handwashing guidelines improved from 76,14% pre-module to 94,2% post-module. This improvement was further reinforced by a student's comment: '*My lectures were enough to prepare me. I know how to protect myself and patients from infections and hazard*s.'

Knowledge of AMR and AMS

Table 4 outlines pre- and post-module scores on AMR and AMS knowledge.
This section had the lowest pre-module median score of 53,8%. Many students expressed concerns about their limited knowledge, with statements such as, "*I don't feel that I have enough knowledge about antimicrobial resistance and stewardship*".
The median score improved from 53.8% pre-module to 61.5% post-module, with a statistically significant increase ($p < 0.001$), indicating a notable improvement in students' knowledge of antimicrobial resistance and stewardship.

As shown in Figure 3, pre-module knowledge gaps on the consequences of AMR were evident in several key areas: Only 28,4% were aware that antimicrobial agents could select for multidrug-resistant organisms, less than 50% understood the protective role of commensal bacteria, 35,2% recognized the link between the use of antimicrobials and the increased risk of fungal infections, and 25% understood that colonization states do not always require treatment. Only 50% acknowledged that HIV is becoming difficult to treat due to resistance to antiretroviral drugs.

Overall, post-module, students displayed significant improvement in AMR-related knowledge, with P<0,001 across all domains, though persistent misconceptions remained. Specifically, students continued to struggle with concepts such as the belief that *"when used correctly, antibiotics shorten the duration of viral and bacterial infections,"* which showed poor scores both pre- and post-module.
Despite improvements, participant feedback emphasized the need for continued learning and reinforcement of AMR concepts, with one student commenting, "*I understand the basics, but I don't feel fully comfortable with AMR*".

Overall, while the module led to substantial gains in knowledge, ongoing education and reinforcement remain essential to address persistent gaps and misconceptions.

Table 4: Pre- and Post-Module Responses on Knowledge of AMR and AMS

Group	n	median	IQR		min	max	p value
Pre-module	88	53,8%	38,5%	57,7%	7,7%	100,0%	< 0.001
Post-module	207	61,5%	53,8%	76,9%	0,0%	92,3%	

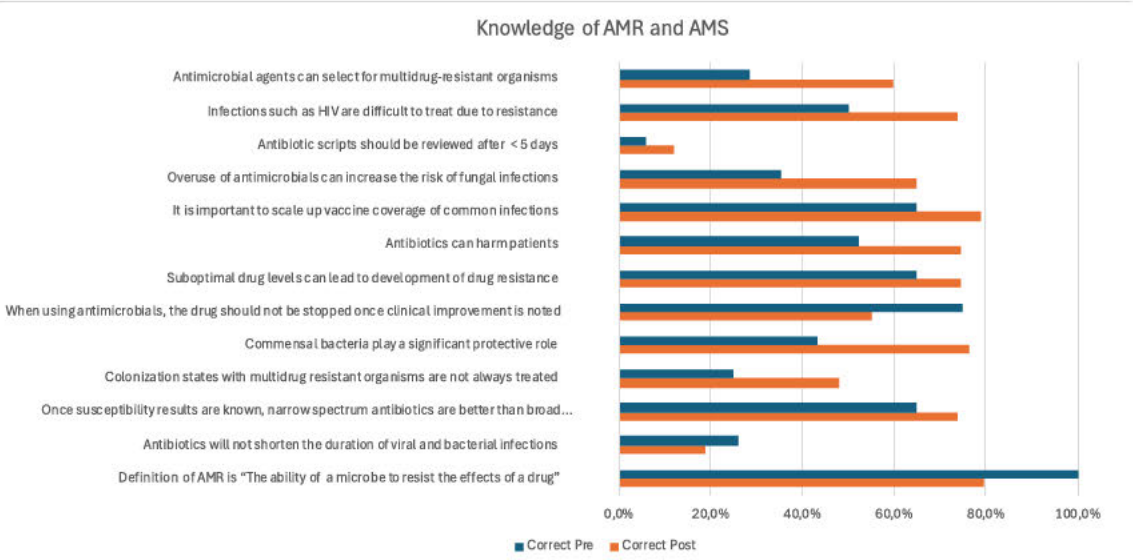

Figure 3: Comparison of Pre- and Post- Module Responses on Knowledge of Antimicrobial Resistance and Stewardship Concepts

Knowledge regarding IPC

Baseline knowledge of IPC was higher than knowledge of AMR and AMS, with pre-module median score of 73,9%, as illustrated in Table 5. Post-module responses demonstrated a significant improvement, with the median score increasing to 87.0% ($p<0,001$).

Student comments included, '*I am aware of universal precautions applied and nosocomial infection prevention'*. This feedback further emphasised increased student confidence in their IPC knowledge post-module.

As illustrated in Figure 6, students scored lowest on topics regarding handling and disposal of medical waste, IPC guidelines and procedures for sterilisation and proper disposal of biohazardous materials. One student reflected on these gaps, stating: "*I need to be taught more on this, even how to properly wash my hands and disposal of sharps, biohazardous material*." Post module, there was notable improvement in knowledge, with 67% of students correctly acknowledging that "*used needles should not be recapped*".

Table 5: Pre- and Post-Module Responses on Knowledge of IPC

Group	n	median	IQR		min	max	p value
Pre-module	88	73,9%	65,2%	82,6%	47,8%	95,7%	< 0.001
Post-module	207	87,0%	78,3%	91,3%	8,7%	100,0%	

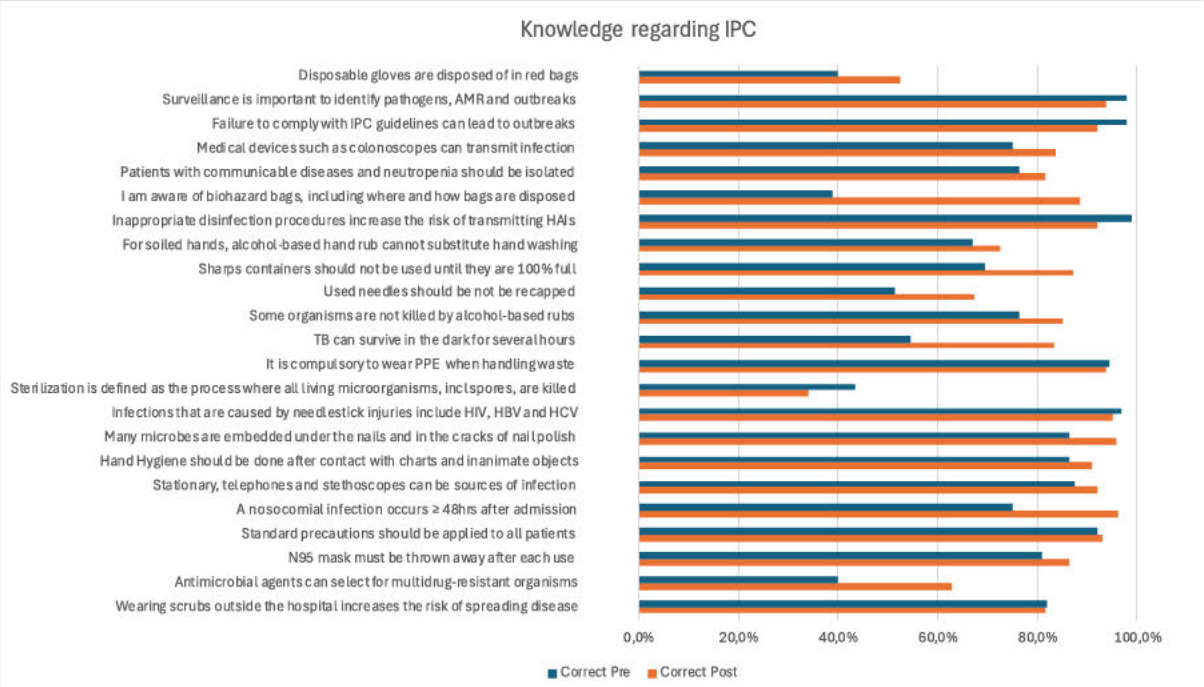

Figure 4: Comparison of Pre- and Post-Module Responses on Knowledge of IPC

Overall, while students demonstrated strong baseline IPC knowledge, the module further enhanced their understanding of IPC practices, reinforcing the importance of safe clinical practices and universal precautions as illustrated in Figure 4.

Perceived Quality of the Infectious Disease Module and Areas for Improvement

Generally, participants provided valuable insights into the perceived quality of education delivered through the module, along with areas for improvement. Post module, 88,5% of respondents reported feeling more motivated to learn about IPC, AMR and AMS, while 88% felt empowered with a solid foundational knowledge before commencing their clinical years.

Students highlighted preferred teaching methods, which included clinical skills practical sessions, recorded online lectures and blended learning approaches. They expressed a benefit from case-based learning, stating *'... interactive case-based tutorials were beneficial'*, '*The case studies broadened my mind and made me see how I should start thinking and applying my mind'.*

Regarding study resources, lecture notes and online learning resources were identified as their primary sources of learning.

Challenges and Areas for Improvement

Despite the positive feedback, students identified several challenges, including content overload in a short timeframe was overwhelming. A strong demand for more practical training**,** particularly in a hospital-based setting, to enhance hands-on experience. Three participants noted, 'I *feel like I need more contact training to prepare myself for the clinical years', 'I lack the practical aspect of what we have learnt'* and '*a hospital component should be added'*. Some students expressed greater confidence in IPC concepts compared to AMR.

They recognized gaps in their knowledge, emphasizing the need for further revision and independent study to deepen their understanding beyond the foundational content

provided in the module. Student comments reflected their awareness of ongoing learning needs, with statements : '*I feel like I still need to learn some information to strengthen my knowledge…'* and '*I do feel more prepared than I was before doing this module. However, I still require more revision and self-learning to become adequately prepared.'*

Overall, while the module was well-received, students highlighted the importance of balancing content delivery with practical application and self-directed learning opportunities to strengthen their competencies.

2.5 Discussion

This study evaluated the impact of a multidisciplinary infectious disease module on third-year medical students' attitudes, perceptions and knowledge of antimicrobial resistance (AMR), antimicrobial stewardship (AMS) and infection prevention and control (IPC).

The findings demonstrated significant improvement in students' awareness, understanding, and confidence across all assessed domains, confirming the value of structured infectious disease training.

A key finding was that students scored higher in *attitudes and perceptions* compared to *knowledge-based* assessments. This aligns with expectations at the third-year level, as foundational knowledge is still developing. However, awareness is a crucial driver of knowledge-seeking behaviour, reinforcing the need for continued education. Baseline IPC knowledge was higher than AMR and AMS knowledge, likely influenced by the extensive dissemination of IPC-related information during the COVID-19 pandemic which increased public and healthcare awareness of IPC. Similar studies were reported by Read et al.[13] and Sartelli et al. [14] who emphasized the importance of sustaining this momentum to reduce healthcare-associated infections and AMR.

Lower awareness and understanding of AMR and AMS likely stem from inadequate public knowledge and the absence of national educational initiatives. Pulcini et al. [15] emphasised the importance of AMS education starting at primary and secondary levels to cultivate awareness among future healthcare professionals and patients. Our students are

introduced to these concepts in their pre-clinical year. The introduction of these concepts earlier in medical training would create early awareness amongst students and create more opportunities for evaluation and redressing any knowledge gaps. Qualitative feedback from this study indicated student support for earlier curriculum inclusion.

Analysis of individual question scores identified areas of improvement and persistent misconceptions, particularly regarding AMS. Similar challenges have been reported in other South African studies, such as Wasserman et al., which highlighted the complexity of AMS concepts and the lack of standardized national curricula.[8] Multidisciplinary collaboration, alongside practical clinical exposure, is necessary to ensure well-defined learning outcomes and effective AMS training.

Although students demonstrated an improved understanding of antimicrobial prescribing, gaps persisted in antibiotic script review, concepts of colonisation and the inappropriate use of antibiotics for viral infections. These concepts require continued reinforcement, and ongoing longitudinal re-assessment throughout medical training. As future prescribers, medical students must appreciate the link between antimicrobial misuse and resistance, underscoring the need for continuous AMS education.

An important aspect of IPC involves protecting healthcare workers. The Department of Health recommends that all healthcare workers (HCWs) should be vaccinated against Hepatitis B.[16] However, only two-thirds of students in this study confirmed completing the full three-dose vaccination series. Similar findings were reported by Makan at the University of Witwatersrand, where a gap in full-dose completion was observed.[17] These findings support recommendations for university policy reviews to ensure mandatory Hepatitis B vaccination, access to cost-effective vaccination programs, and post-vaccine serology testing.[17]

Although majority of students felt confident in safely handling sharps, fewer agreed that needles should not be recapped. Training regarding the prevention of needlestick injuries (NSIs) needs to be prioritised. Keicher et al.[18] proposed several strategies to improve NSI prevention, including supervisor involvement in clinical settings, instructional videos on NSI risks and reporting, enhanced lab training on procedural attentiveness,

collaboration with occupational health departments, and follow-up surveys post-training. Incorporating these strategies into IPC training could enhance student preparedness.
Consistent with other studies, poor compliance with hand hygiene amongst HCWs remains a widespread issue. While most students in this study reported awareness of WHO handwashing guidelines, practical skills were not assessed, warranting further study. Additionally, knowledge gaps were identified in sterilisation, disinfection and waste management. As newly introduced concepts, these topics require reinforcement in subsequent academic years.

Student feedback reflected strong foundational theoretical knowledge but highlighted the need for practical exposure as many students expressed confidence in their understanding but acknowledged the importance of hands-on experience to apply IPC measures effectively in clinical practice. As future doctors, developing correct IPC behaviours early in their careers is essential for long-term patient safety. Ongoing education, observation, and audits of medical students' IPC practices during clinical training are necessary to ensure adherence and implementation.
Students identified small group clinical skills lab sessions, pre-recorded lectures, and blended learning as the most effective teaching methods. Lecture notes and online resources were preferred for self-directed learning, with many students favouring interactive, practical, and case-based sessions. These preferences should be considered for optimizing future teaching pedagogies.

Statistics confirmed that students exited the module with significantly improved knowledge and awareness of IPC, AMR and AMS, while also identifying areas for improvement. According to Goyal et al.[9], medical students must recognise their role in managing and limiting the spread of antimicrobial-resistant pathogens. This study increased student engagement and motivation, and served as a "wake-up call", as many reported that the pre-module questionnaire highlighted their knowledge gaps and encouraged them to be more attentive during the course.

Limitations and Recommendations

The study was conducted at a single institution, limiting the generalizability of the findings to other medical schools or educational contexts. The short data collection period did not allow for the assessment of long-term knowledge retention. The lower response rate in the pre-module questionnaire compared to the post-module survey may have introduced selection bias, as more engaged or motivated students were likely to participate. Additionally, reliance on self-reported data may have affected results, as students completed the post-module questionnaire immediately after their examination, potentially affecting their responses. To address these limitations, future studies should assess foundational AMR, AMS and IPC knowledge levels across multiple institutions to develop standardized curricula for medical schools.

The curriculum should commence in year one of medical school, and training must continue into internship and the post-graduate years through CPD workshops, journal clubs etc. The curriculum should be developed by academia in collaboration with experts in the field and have clearly defined learning outcomes. A variety of teaching methodologies, e.g. integrating AMS into case-based learning, should be used. These must be supported with resource lists[14] which direct students to online learning material such as guidelines, antibiograms and IPC care bundles. Learning outcomes should be measured using standardized assessments.

Interdepartmental and interprofessional educational sessions should be introduced to foster collaboration between medical students and other healthcare professionals, such as pharmacists, and microbiologists. Ongoing AMS and IPC training throughout the clinical years will help reinforce knowledge, address misconceptions, and promote retention. Clinician involvement in IPC and AMS training in hospitals will provide students with greater clinical exposure.

Follow-up studies should assess long-term knowledge retention and its application in clinical practice. Continuous student feedback and curriculum updates are essential to maintaining relevance and effectiveness.

2.6 Conclusions

This study highlights the critical role of structured infectious disease training in improving medical students' knowledge, attitudes, and perceptions of AMS, AMR and IPC. Significant post-module improvements were observed across all domains, with qualitative feedback indicating increased motivation and confidence in applying IPC and AMS principles.

Given the global threat of AMR, raising awareness and educating undergraduate students is a key strategy for addressing this issue. Establishing a strong foundation for IPC and antimicrobial use practice behaviours during pre-clinical years allows for reinforcement and assessment throughout medical training.

With increased student awareness, multidisciplinary collaboration, optimized teaching methodologies, and adequate resources, medical schools can effectively prepare students for responsible antimicrobial use and infection prevention. Prioritising the pre-clinical years will help establish good practices and instil positive clinical behaviour patterns essential for future patient safety.

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Annexures

Annexure 1:

List of teaching topics included in 3rd-year Infectious Disease Module, Nelson R Mandela School of Medicine, University of KwaZulu-Natal, 2023:

Microbiology	Virology	Clinical Skills	Other
An introduction to Infectious Diseases	Lab diagnosis of viral infections	Prevention of needlestick injuries, HIV testing and PEP	Introduction to epidemiology of infectious disease

Antimicrobial agents	Validity of lab tests (2 lectures)	Approach to history taking in fever	Thermoregulation
Antifungals	Emerging viral infections	Specimen & swabs, blood collection & blood culture collection	Malaria control at community level
Vaccines	Viral vaccines	Measurement of body temperature and TB testing in children	Role of Vaccines in the prevention of infectious diseases
Rational use of antimicrobials (2 lectures)	HIV virology	Waste disposal	URTI in children
Pyrexia of unknown origin	Lab diagnosis of HIV	Gloving and gowning	Febrile neutropenia
Microbiology lab in Diagnosis of Infectious Diseases	Antiretroviral drugs and resistance	Sterilization and disinfection	Immunodeficiency
Fever in travellers	Viral infections of the skin and mucosa		Approach to Outbreak investigation
Anaerobe infections	Viral infections in immunocompromised patients		Introduction to molecular biology and epidemiology
NTM and TB	VHF		Medical ethics of HIV and TB
Anti-TB drugs			Global trends in anti-microbial use

Microbes causing hospital acquired infections			Drug dosage
Prevention of spread of hospital acquired infection			Malaria prophylaxis
Approach and management of hospital acquired outbreaks			
Opportunistic infections			

APPENDICES

APPENDIX 1

Study Protocol

UNIVERSITY OF KWAZULU-NATAL
COLLEGE OF HEALTH SCIENCES
SCHOOL OF CLINICAL MEDICINE

IMPACT OF AN INFECTIOUS DISEASE TRAINING MODULE ON THE AWARENESS REGARDING ANTIMICROBIAL STEWARDSHIP, INFECTION PREVENTION AND CONTROL PRACTICES AMONG THIRD YEAR MEDICAL STUDENTS IN KWAZULU-NATAL

RESEARCH PROPOSAL

SUBMITTED BY
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FOR A THESIS IN FULFILMENT OF THE REQUIREMENTS OF THE DEGREE OF MASTERS IN MEDICAL MICROBIOLOGY

SUPERVISOR: PROF. KHINE SWE SWE-HAN
CO-SUPERVISOR: DR REINA MARY ABRAHAM

1. Defining the Research Problem

World Health Organization (WHO) has declared that antimicrobial resistance (AMR) is one of the top 10 global public health threats facing humanity (WHO,n.d.). Using predictive statistical models, Murray et al (2022) estimated that globally there were 4.95 million deaths associated with AMR in 2019, with sub-Saharan Africa having the greatest burden. Multidrug-resistant organisms are increasing in our hospitals. Most infections with these resistant pathogens are acquired in hospital i.e. they are nosocomial or Healthcare Associated Infections (HCAI) and are associated with significant morbidity and mortality, increased length of hospital stay and management cost. Importantly, these infections are preventable.

WHO states that infection prevention and control (IPC) and the rationale use of antimicrobials is essential in curbing AMR. In May 2015 the World Health Assembly adopted a global action plan on antimicrobial resistance. They advise teaching infection prevention and control (IPC) and principles of antimicrobial use in curriculums at Medical schools (WHO, 2009). Medical students need to appreciate their role in the management and limiting the spread of antimicrobial-resistant pathogens (Goyal et al, 2019). Furthermore, as future prescribers, medical students must appreciate the link between antimicrobial misuse and resistance. It is vital that they are educated regarding the principles of antimicrobial use and the importance of adhering to prescribing principles (Aboo et al, 2013).

The pre-clinical years are a vital time for inculcating positive behaviours and laying the foundation for good practice. Are our pre-clinical students adequately prepared to transition from the preclinical to clinical years in the wards where they will interact with patients, pathogens and antimicrobials? We are not aware of any previous studies conducted at UKZN to evaluate this. Hence, this study aims to assess their knowledge, perceptions and attitudes towards AMR and IPC. The study will conclude by identifying any gaps that can be addressed.

2. Literature Overview and Motivation

Historical background

The Centre for Disease Control and Prevention(CDC) defines an antimicrobial as "A substance, such as antimicrobial agents, that kills or stops the growth of microbes, including bacteria, fungi, or viruses"(CDC,2019).

CDC defines antimicrobial resistance as "The ability of a microbe (germ) to resist the effects of a drug. Antimicrobial-resistant germs are not killed by the drugs that are typically used against them and may continue to multiply. Antimicrobial resistance includes antibacterial, antifungal, and antiviral resistance."

When antimicrobials lose their effectivity, infections become difficult to treat or cannot be treated at all. Ineffective treatment of drug-resistant pathogens results in increased morbidity and mortality, increased length of hospital stay, increased need for intensive care and increased cost. Resistant organisms pose a significant public health threat (CDC, 2019). Even elective procedures such as caesarean section, transplant surgery and chemotherapy will become more risk-laden (WHO,n.d.).

The WHO has expressed concern regarding the global spread of "superbugs" or multi- and pan-resistant bacteria against which existing antimicrobials are ineffective (WHO - n.d.). Of additional concern, is the limited development of new, effective antimicrobials (WHO, n.d.). In addition, there is limited availability of vaccines against the leading drug-resistant pathogens (Murray et al, 2019).

To address these concerns, in May 2015, the World Health Assembly adopted a global action plan on antimicrobial resistance. The plan has 5 key objectives including raising awareness and knowledge about AMR through education, optimising the use of antimicrobials, promoting IPC to decrease infection rates, conducting surveillance and research and increasing investment into new medicines and interventions (WHO Global Action Plan on AMR, 2015).
This is a multifaceted strategy, and adequately educating and empowering our medical students is a key step in its implementation.

Why is this subject important?

Healthcare-associated Infection and Infection Prevention and Control

WHO defines healthcare-associated infection (HCAI) as "An infection occurring in a patient during care in a hospital or other healthcare facility, which was not present or incubating at the time of admission. Health-care associated infections can also appear after discharge. They represent the most frequent adverse event associated with patient care" (WHO, 2019).

In their "WHO Patient Safety Curriculum Guide for Medical Schools", WHO refers to a new science of "patient safety" and states that "harm to patients is not inevitable and can be avoided" (2009). Strict compliance with simple infection control measures such as standard precautions, can prevent the spread of pathogens (Goyal et al, 2019; Ibrahim et al, 2016), thereby protecting patients, visitors and healthcare workers (HCWs).

WHO highlight the urgent need to adopt a shift of focus from just the management of disease to a more holistic undergraduate curriculum that includes the prevention of illness (WHO, 2019). Thus, all medical schools should include patient safety as part of their curriculum.

Medical students are exposed to infectious diseases as an occupational hazard (Ibrahim et al, 2016). They also serve as a vector for the spread of resistant organisms (Chauhan, 2017).
It is therefore essential that they enter their clinical years with an awareness and adequate knowledge of the basic principles of infection prevention and control (IPC). They need a basic understanding of routes of infection, standard, contact and droplet precautions. As the doctors of tomorrow, they must take responsibility and remain accountable for their own and their patients' safety.

As future doctors, it is vital to inculcate these positive behaviours early in their careers as this will have a long-standing impact on future patient management outcomes. In

addition, the ongoing implementation and adherence to these measures is of paramount importance.

A study by Ibrahim et al (2016) in Qatar, concluded that medical students' knowledge of IPC was inadequate. In their study, Goyal et al (2019) found that there is non-compliance to basic IPC measures such as hand washing among HCWs. They suggested regular training and reinforcement of knowledge. Both studies suggest that this training should be included early in the undergraduate medical programme.

Antimicrobial stewardship

A study by Wasserman et al. (2017) showed that only 33% of medical students in South Africa feel confident with regard to prescribing antimicrobials. Yet, antimicrobials are regularly prescribed by interns, junior doctors and doctors across a spectrum of disciplines. However, the level of training regarding correct use of antibiotics varies widely and only select patient cases are referred to infectious disease specialists (Abbo et al, 2013).

Yuste et al (2022) state that antibiotic prescriptions can be further optimised in 30-50 percent of cases and that doctors with less training with regards to antibiotic prescribing tend to use more broad-spectrum agents. Common errors in prescribing include incorrect duration of therapy, omitting to de-escalate from a broad spectrum to a narrow spectrum antimicrobial, or to switch from intravenous to oral route of administration, treating non-infectious syndromes with antimicrobials, treating colonisation or contamination (Yuste et al, 2022). Suboptimal prescribing practices have been linked to the development of AMR (Wasserman et al, 2017).

There are very few new antibiotics being developed. Thus, we need to optimize the use of existing antibiotics to prevent the development of resistance. This will extend their lifespan of effectiveness and is totally dependent on the adoption of correct prescribing behaviours (WHO AMS, 2019). WHO defines antimicrobial stewardship as "a coherent set of actions which promote the responsible use of antimicrobials" (WHO, 2019).

Abbo et al (2013), suggested that antimicrobial stewardship be taught during medical school. Wasserman et al (2017) stated that medical students may be inadequately educated regarding prescribing of antimicrobials during their undergraduate years and may not fully appreciate the consequences of AMR. On a positive note, their study showed that 95% of students would like more training on antibiotics.

Abbo et al (2013), highlighted that there is a need to assess the curricula and teaching pedagogy regarding antimicrobial stewardship. According to Wasserman et al (2017), there are differences in curriculum content across South African universities and no standardisation of teaching content. It is therefore imperative that we review our student's knowledge and awareness regarding this concept.

Relevance of this study

The global threat of AMR requires urgent action. A key strategy to address this is to raise awareness and educate our undergraduate students. The foundation for IPC and antimicrobial use practice behaviours should be laid during the pre-clinical years. Previous studies show that medical students are willing to receive more training in these fields (Abbo et al, 2013). Yuste et al (2022) report that training should be ongoing and pedagogical changes may be required as students lose knowledge with time. A baseline assessment of the University of KwaZulu Natal's 3rd-year pre-clinical students' perceptions and knowledge of AMR and IPC is therefore warranted and a priority. Any gaps identified can be addressed with improved teaching strategies.

3. Aim and Objectives

Aim

The aim of the study is to access the attitudes, perceptions and knowledge of preclinical medical students (3rd year MBChB in 2023) regarding infection prevention and control and the spread of antimicrobial-resistant organisms.

Objectives

1. To assess knowledge and awareness of antimicrobial resistance, stewardship and infection prevention and control in medical students in UKZN using standard question set-up.

2. To evaluate the impact of infectious disease training in eliminating any existing gaps in knowledge and awareness of antimicrobial resistance and infection prevention and control

4. Methods

4.1. Setting

This study will be conducted amongst third year pre-clinical medical students at the Nelson R Mandela School of Medicine at the University of KwaZulu-Natal. The undergraduate medical degree is a 6 year course. The first 3 pre-clinical years focus on basic sciences and foundational knowledge. This is followed by clinical years 4-6 where hospital-based training occurs.

The final module taught in year 3 is a multidisciplinary 4 week "Infectious Disease" module. This module is dedicated to teaching the fundamentals of infectious diseases including concepts in microbiology, virology, pharmacology, molecular biology, haematology, infectious diseases and ethics. Lectures pertaining to IPC, AMR and rationale use of antimicrobials are included. Topics covered during the module are listed in Table 1. Knowledge of these are essential for a safe transition to fourth year clinical training.

Table 1. List of teaching topics included in 3rd year Infectious Disease Module, Nelson R Mandela School of Medicine, University of KwaZulu-Natal, 2023.

Microbiology	Virology	Clinical Skills	Other
An introduction to Infectious Diseases	Lab diagnosis of viral infections	Prevention of needlestick injuries, HIV testing and PEP	Introduction to epidemiology of infectious disease
Antimicrobial agents	Validity of lab tests (2 lectures)	Approach to history taking in fever	Thermoregulation
Antifungals	Emerging viral infections	Specimen & swabs, blood collection & blood culture collection	Malaria control at community level
Vaccines	Viral vaccines	Measurement of body temperature and TB testing in children	Role of Vaccines in the prevention of infectious diseases
Rational use of antimicrobials (2 lectures)	HIV virology	Waste disposal	URTI in children
Pyrexia of unknown origin	Lab diagnosis of HIV	Gloving and gowning	Febrile neutropenia
Microbiology lab in Diagnosis	Antiretroviral drugs and resistance	Sterilization and disinfection	Immunodeficiency

of Infectious Diseases			
Fever in travellers	Viral infections of the skin and mucosa		Approach to Outbreak investigation
Anaerobe infections	Viral infections in immunocompromised patients		Introduction to molecular biology and epidemiology
NTM and TB	VHF		Medical ethics of HIV and TB
Anti-TB drugs			Global trends in anti-microbial use
Microbes causing hospital acquired infections			Drug dosage
Prevention of spread of hospital acquired infection			Malaria prophylaxis
Approach and management of hospital acquired outbreaks			
Opportunistic infections			

4.2. Study Design

The method of this study would be determined by the research questions. To investigate medical students' awareness of the importance of adhering to antimicrobial resistance and infection prevention and control guidelines, each of the entities considered must be measured.
This can be accomplished by evaluating medical students' knowledge of antimicrobial resistance, stewardship, and infection prevention and control. The impact of an infectious disease training module on closing any gaps in their knowledge and awareness regarding antimicrobial resistance and infection prevention and control will also be assessed.

A cross-sectional study using a mixed method approach i.e., both quantitative and qualitative approaches will be adopted for this study. Qualitative methods are known to give meaningful understanding of perceptions and interventions, but are harder to extrapolate, whereas quantitative studies can be replicated and generalized. When these two methods are applied in one study, they tend to complement each other therefore making the study more valid and rigorous (Chi, 1997). A mixed method approach will allow for collection, analysis, and comparison to give a holistic understanding of the research problem. This research will incorporate a qualitative component into an otherwise quantitative study adding validity (Creswell, 2013). Merging the results of the two components for comparison and interpretation will produce a convergent mixed method design.

4.3. Participant Selection

The study will recruit current third year medical students who are of varying age, sex and ethnicity. This will be done at the end of a large group lecture using a paper copy of the questionnaire. As part of the recruitment strategy, all students will be informed of the study by the researcher. The method of data collection via questionnaire before and after the Infectious Disease module will be explained. It will be explained that the

questionnaire is not part of any formal assessment and responses will be anonymous. Students will be invited to volunteer to participate after explaining that their assistance would help identify current knowledge and any gaps with a view to modify and improve the Infectious Disease
module curriculum. Written consent will be obtained and students will be informed that they can withdraw participation at any time. If approved by the ethics committee, each student will be offered a token of appreciation for completing the questionnaire.

4.4. Measurements

Data on student's attitudes, perceptions and knowledge of key areas of IPC and AMR will be collected using an anonymous standard questionnaire with a mix of open and closed rated questions as the data collection instrument. The WHO and CDC guidelines regarding IPC, antimicrobial stewardship and AMR will be drawn upon to frame the content of the questionnaire. In addition, the content of similar studies (Ibrahim et al, 2016; Wasserman et al, 2017; Goyal et al, 2019; Tavolacci et al, 2008; Chauhan K, 2017; Nowbath et al, 2023) will be adapted for this study.

The questionnaire will be divided into 7 sections:
Demographic data
Perceptions and Attitudes regarding Antimicrobial Resistance and
Antimicrobial Stewardship
Attitudes and perceptions regarding IPC
Knowledge of Antimicrobial Resistance and Stewardship
Knowledge regarding IPC
Open ended questions
Open ended questions added to questionnaire after completion of module

Students will review a series of statements in each section. For sections 2 and 3 they will be given the option to either agree, disagree or select unsure for each, while for

sections 4 and 5 they will select either true, false or unsure. All questions will be quantitative with the open-ended questions forming the qualitative assessment.

The questionnaire will be piloted with a few students to test the adequacy of the questions before administering to the entire class. Content validity will be tested statistically.
Sampling bias will be minimised as the entire class will be given the option to participate. The survey format will be simple and a paper copy will be used so that it is accessible to all.

Students will answer this questionnaire prior to commencing the "Infectious disease" module in order to assess their baseline knowledge prior to formal training. They will answer the same questionnaire a second time, after completion of the module and with the addition of a few more questions, to assess the impact of the educational intervention.

The study will conclude by identifying any gaps in student knowledge and their preparedness to transition from preclinical to clinical years in the wards where students will interact with patients and pathogens.

4.5. Data Analysis

Multivariate analyses will be used. For the quantitative data : descriptive statistics (mean, median) will be used to describe the sample and evaluate responses to the closed ended questions in the questionnaire before and after the module. Paired t-test will be used to compare difference in response scores before and after the module.
For qualitative data to open-ended questions: responses will be thematically analysed by coding and categorising the data to make meaning to the response.
Each data set will initially be analysed separately and then merged concurrently to facilitate more comprehensive viewpoints of the research problem by including both subjective and objective evidence. By employing this mixed methods approach, the

study will result in a more complete, rigorous piece of research as it enriches the data gathered from quantitative questions (Creswell, 2013). Quantitative data will also be illustrated using tables and figures.

All data will be stored for 5 years on my computer with password protection. Hardcopy questionnaires will be locked in my office cupboard and shredded after 5 years.

4.5.1. Sample Size

We aim to recruit the entire third year class which is roughly 250 students.

5. Ethical Considerations

Ethical approval for the study will be sought from Humanities and Social Sciences Research Ethics Committee, University of KwaZulu-Natal. All study participants will complete an informed consent form. Data Collection will commence only after Ethical and gatekeeper approval from the University Registrar is obtained.

6. Budget

7. Timelines and Project Management

Proposed Timeline

STEPS	DATES
Submission of proposal	August 2023
Literature Review	Sept 2023
Distribution of questionnaires and data collection	After ethical approval – October 2023
Analysis of results	Nov 2023
Submission of completed research	June 2024

8. Contributors and Authorship

Dr Asmeeta Burra, MMed student UKZN

Dr Reina Abraham, Department of Clinical Skills, Co-supervisor

Prof Khine Swe Swe-Han, Department of Microbiology, Supervisor

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APPENDIX 2

Data Collection Tool

Questionnaire

Please indicate your answer with a tick

Section A - Demographics

1. My gender is:

   ☐ Male

   ☐ Female

   ☐ Other

2. I belong to the following age group:

   ☐ 18-25

   ☐ >25

   ☐ >35

3. I am studying Medicine

   ☐ As my first degree

   ☐ I have another tertiary qualification

If you hold another qualification, please specify:

_____

Section B: Perceptions and Attitudes regarding Antimicrobial Resistance and antimicrobial stewardship

	Agree	Disagree	Unsure
1. WHO has declared that AMR is one of the top 10 global public health threats facing humanity			
2. AMR is associated with significant morbidity, mortality, longer hospital stays and higher costs			
3. Antimicrobial resistance can occur naturally and also due to incorrect dosing			
4.Antibiotics are overused in South Africa			
5. I understand the basic mechanisms of drug resistance			
6. There are currently many new antimicrobials being developed and this will adequately address the issue of antimicrobial resistance			
7. A good knowledge of prescribing is important to me as a future doctor, and I would like more training on antimicrobial use			
8.As a qualified doctor, it will be essential that I can make decisions by myself instead of consulting a multidisciplinary team			
9. I should include my patient in decision making and adequately counsel my patients regarding need for compliance and infection control measures			

10. After I qualify, I should keep up to date with recent advances and literature regarding antimicrobial use			
11. It is important that I recognize my limitations and seek advice from my seniors and experts in the field such as microbiologists and infectious disease doctors			
12. As a future doctor I should follow correct prescribing in order to protect the effectiveness of antimicrobials			
13. When prescribing I should follow expert guidelines. I am aware of where to source these guidelines			
14. I understand the concept “antimicrobial stewardship”			
15. I understand the concept “empirical therapy”			
16. I understand the concept “direct therapy”			
17. I understand the meaning of “chemoprophylaxis”			
18. I understand the role of the microbiology laboratory with regards to antimicrobial stewardship			

Section C: Attitudes and perceptions regarding IPC:

	Agree	Disagree	Unsure
1. As a medical student, my role in spreading nosocomial infections is negligible			

2. You should not assume a patient is infectious unless this is confirmed by laboratory tests			
3.IPC precautions are time consuming and difficult to follow.			
4. Nosocomial infections are unavoidable			
5. It is acceptable for medical staff to wear jewelry such as rings and watches, if they use gloves			
6. As a future doctor I should follow the advice of infection prevention and control specialists and take corrective instruction from them			
7. I am aware of World Health Organization hand washing guidelines			
8. I know how to safely handle sharps			
9. Infection Prevention and Control is unnecessarily hyped			
10. I have taken 3 doses of Hepatitis B vaccine			
11. Nosocomial infections are associated with serious consequences such as increased mortality			
12. For microbiological specimens, completing the clinical information required on request form is not essential for appropriate evaluation and interpretation of microbiological cultures			
13. I understand the relevance of IPC, AMR and antimicrobial stewardship			

Section D: Knowledge of antimicrobial resistance and stewardship

	True	False	Unsure
1. Definition of AMR is "The ability of a microbe to resist the effects of a drug" and this results in poor or no clinical response of an infectious disease to that drug (T)			
2. When correctly used, antibiotics will shorten the duration of viral and bacterial infections (F)			
3. Once antimicrobial susceptibility results are known, using broad spectrum antibiotics is better than narrow spectrum antibiotics (F)			
4. Colonization states with multidrug resistant organisms should be treated with antimicrobials even in the absence of infection (F)			
5. Commensal bacteria play a significant protective role by preventing colonization by pathogenic microorganisms (T)			
6. When using antimicrobials, the drug should be stopped once clinical improvement is noted, so as to avoid overuse (F)			
7. Suboptimal drug levels can lead to development of drug resistance (T)			
8. Antibiotics can harm patients (T)			
9. It is important to scale up vaccine coverage of common infections in order to prevent these infections and therefore stop development of antimicrobial drug resistance to these organisms (T)			
10. Overuse of antimicrobials can increase the risk of fungal infections (T)			
11. Antibiotic scripts should be reviewed after 5 days (F - correct answer 48-72 hours)			

12. Infections such as HIV are becoming harder to treat due to development of resistance to antiretroviral drugs (T)			
13. Antimicrobial agents can select for multidrug-resistant organisms (T)			

Section E: Knowledge regarding IPC:

	True	False	Unsure
1. Wearing your white coat or scrubs outside the hospital setting (e.g. at lunch) is associated with an increased risk for spread of diseases (T)			
2. Antimicrobial agents can select for multidrug-resistant organisms thereby predisposing patients to health care associated infections (T)			
3. N95 mask must be thrown away after each use (T)			
4. Standard precautions comprise a group of practises that should be applied to all patients (T)			
5. A nosocomial infection –is an infection occurring in a patient in a hospital or other health care facility in whom the infection was not present or incubating at the time of admission. Usually occur ≥48hrs after admission (T)			
6. On the ward, stationary, telephones and stethoscopes can be sources of infection (T)			
7. Hand Hygiene should be done after contact with charts and other inanimate objects that are used in patient settings (T)			
8. Many microbes are embedded under the nails and in the micro & macro cracks of nail polish (T)			
9. Infections that can be caused by needle-stick injuries include Human Immunodeficiency Virus (HIV), Hepatitis B Virus (HBV) and Hepatitis C Virus (HCV) (T)			

10. Sterilization is defined as the process where all the living microorganisms, excluding bacterial spores are killed (F)			
11. It is compulsory to wear personal protective equipment especially when handling waste of any sort (T)			
12.TB can survive in the dark for several hours (T)			
13.Alcohol-based hand-rubbing should be performed before manipulation of intra-venous devices or insertion of a urethral catheter. However, some organisms are not killed by alcohol-based rubs (T)			
14.Used needles should be recapped after use to prevent injuries (T)			
15.Sharps containers should be used until they are 100% full (F)			
16. For soiled hands, alcohol-based hand rub can substitute hand washing (F)			
17. Inappropriate disinfection procedures increase the risk of transmitting HAIs among hospitalized patients (T)			
18. I am aware of biohazard bags and know where and how the contents of these bags are disposed			
19. Patients with communicable diseases and neutropenic patients should be isolated in private rooms(T)			
20. Medical devices such as colonoscopes can transmit infection from patient to patient, from patient to healthcare worker and from the environment to the patient (T)			
21. Failure to comply with infection control and prevention guidelines can lead to outbreaks of infectious diseases (T)			
22. Surveillance is important to identify and track pathogens, their evolution, antimicrobial resistance and outbreaks (T)			
23. Light biohazardous waste such as disposable gloves are disposed of in red bags (T)			

Section F: Open ended questions:

1. With regards to IPC, AMR and antimicrobial stewardship, do you feel adequately prepared to commence your clinical years? If not, please explain.

2. Do you feel motivated to learn more about IPC, AMR and antimicrobial stewardship?

The following questions will be added to questionnaire after completion of the infectious disease module:

3. I understood the rationale behind concepts taught during the Infectious disease module, and feel empowered with a good foundational knowledge prior to commencing my clinical years

4. What method of teaching did you find most effective?
   E.g., large group lectures, PBL, practical sessions such as Clinical Skills

5. What resources did you find most useful?
   E.g., Internet, guidelines, lecture notes, textbooks

6. Do you have any suggestions to improve the training received during the Infectious disease module?

APPENDIX 3

Informed Consent

UKZN HUMANITIES AND SOCIAL SCIENCES RESEARCH ETHICS COMMITTEE (HSSREC)

APPLICATION FOR ETHICS APPROVAL

For research with human participants

INFORMED CONSENT

Information Sheet and Consent to Participate in Research

Date:

Good day

My name is Dr Asmeeta Burra and I am currently enrolled for a Masters degree in the Department of Microbiology, School of Laboratory Medicine, UKZN. My e-mail address is 933481203@stu.ukzn.ac.za.

You are invited to consider participating in a study that involves research on pre-clinical third year students' preparedness to transition to their clinical years with an aim to access attitudes, perceptions and knowledge of antimicrobial resistance and infection prevention and control practices.

The purpose of this research is to identify any existing gaps in knowledge and awareness. The results of the study will serve as a guide for future teaching curricula development.

The study is expected to enroll the entire third year class at the Nelson R Mandela School of Medicine at the University of KwaZulu-Natal, which is roughly 250 students.

Participation in this study will involve two phases of data collection:
You will complete an anonymous questionnaire with a mix of open and closed rated question prior to commencing the "Infectious disease" module in order to assess your

baseline knowledge prior to formal training.
You will then answer a second questionnaire after completion of the module, to assess the impact of the educational intervention.
Your responses will be kept confidential, and your identity will not be used in the study report.

The duration of your participation if you choose to enroll and remain in the study is expected to be roughly 6 weeks.

There are no risks to your answering the questionnaire. The questionnaire is not part of any formal assessment and responses will be anonymous. The results of the study will serve as a guide for future teaching curricula development.

This study has been ethically reviewed and approved by the UKZN Humanities and Social Sciences Research Ethics Committee (approval number_____).

In the event of any problems or concerns/questions you may contact the researcher Dr A. Burra at 933481203@stu.ukzn.ac.za or Dr R Abraham (abrahamr@ukzn.ac.za) or Prof. K.Swe Swe-Han (Sweswe-han@ukzn.ac.za) or the UKZN Humanities & Social Sciences Research Ethics Committee, contact details as follows:

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION
Research Office, Westville Campus
Govan Mbeki Building
Private Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604557-Fax: 27 31 2604609
Email: HSSREC@ukzn.ac.za

Participation in this research is voluntary and you may withdraw participation at any point. In the event of your refusal/withdrawal of participation you will not incur any penalty or loss of other benefit to which you are normally entitled. You may e-mail any of the e-mail addresses listed above to withdraw from the study.

You will not incur any costs if you participate in the study. At the end of the study, after completing the second questionnaire, you may receive a small token of appreciation e.g. a chocolate.

Questionnaires do not include any information that may directly disclose your identity. All data reported in the literature will be anonymized. Data will be stored on my computer that will be Password protected. Electronic data will eventually be disposed of by permanently deleting files and physical data will be shredded and disposed of in secured bins.

CONSENT

I (Name) have been informed about the study entitled "Impact of an Infectious Disease Training module on the awareness, regarding antimicrobial stewardship, infection prevention and control practices among third year medical students in KwaZulu-Natal" by Dr Asmeeta Burra.

I understand the purpose and procedures of the study.

I have been given an opportunity to ask questions about the study and have had answers to my satisfaction.

I declare that my participation in this study is entirely voluntary and that I may withdraw at any time without affecting any of the benefits that I usually am entitled to.

If I have any further questions/concerns or queries related to the study, I understand that I may contact the researcher at 933481203@stu.ukzn.ac.za.

If I have any questions or concerns about my rights as a study participant, or if I am concerned about an aspect of the study or the researchers then I may contact:

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION
Private Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604557 - Fax: 27 31 2604609
Email: HSSREC@ukzn.ac.za

_____ _____

Signature of Participant **Date**

APPENDIX 4

Ethics Approval Letter

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

05 October 2023

Dr Asmeeta Burra (933481203)
School of Lab Med & Medical Sc
Medical School Campus

Dear Dr Burra,

Protocol reference number: HSSREC/00006160/2023
Project title: Impact of an infectious disease training module on the awareness regarding antimicrobial stewardship, infection prevention and control practices among third year medical students in KwaZulu-Natal
Degree: MMed

Approval Notification – Expedited Application

This letter serves to notify you that your application received on 13 September 2023 in connection with the above, was reviewed by the Humanities and Social Sciences Research Ethics Committee (HSSREC) and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

This approval is valid until 05 October 2024.
To ensure uninterrupted approval of this study beyond the approval expiry date, a progress report must be submitted to the Research Office on the appropriate form 2 - 3 months before the expiry date. A close-out report to be submitted when study is finished.

HSSREC is registered with the South African National Health Research Ethics Council (REC-040414-040).

Yours sincerely,

[redacted]

Professor Dipane Hlalele (Chair)

/dd

APPENDIX 5

UKZN Gatekeeper Approval Letter

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

4 October 2023

Dr Asmeeta Burra
School of Clinical Medicine
College of Health Sciences
NRMSM Campus UKZN
Email: burraa@ukzn.ac.za

Dear Dr Burra

RE: PERMISSION TO CONDUCT RESEARCH

Gatekeeper's permission is hereby granted for you to conduct research at the University of KwaZulu-Natal (UKZN), towards your postgraduate degree, provided Ethical clearance has been obtained. We note the title of your research project is:

"Impact of an Infectious Disease Training module on the awareness regarding antimicrobial stewardship, infection prevention and control practices among third year medical students in KwaZulu-Natal."

It is noted that you will be constituting your sample by handing out questionnaires to third year undergraduate (MBChB) medical students on the NRMSM campus.

Please ensure that the following appears on your notice/questionnaire:

- Ethical clearance number;
- Research title and details of the research, the researcher and the supervisor;
- Consent form is attached to the notice/questionnaire and to be signed by user before he/she fills in questionnaire;
- gatekeepers approval by the Registrar.

You are not authorized to contact staff and students using the 'Microsoft Outlook' address book. Identity numbers and email addresses of individuals are not a matter of public record and are protected according to Section 14 of the South African Constitution, as well as the Protection of Public Information Act. For the release of such information over to yourself for research purposes, the University of KwaZulu-Natal will need express consent from the relevant data subjects. Data collected must be treated with due confidentiality and anonymity.

Yours sincerely

[redacted]

Mr MA TUFTS: Director Governance & Administration

APPENDIX 6

Teaching Topics included in 3rd year Infectious Disease Module

List of teaching topics included in 3rd-year Infectious Disease Module, Nelson R Mandela School of Medicine, University of KwaZulu-Natal, 2023:

Microbiology	Virology	Clinical Skills	Other
An introduction to Infectious Diseases	Lab diagnosis of viral infections	Prevention of needlestick injuries, HIV testing and PEP	Introduction to epidemiology of infectious disease
Antimicrobial agents	Validity of lab tests (2 lectures)	Approach to history taking in fever	Thermoregulation
Antifungals	Emerging viral infections	Specimen & swabs, blood collection & blood culture collection	Malaria control at community level
Vaccines	Viral vaccines	Measurement of body temperature and TB testing in children	Role of Vaccines in the prevention of infectious diseases
Rational use of antimicrobials (2 lectures)	HIV virology	Waste disposal	URTI in children
Pyrexia of unknown origin	Lab diagnosis of HIV	Gloving and gowning	Febrile neutropenia
Microbiology lab in Diagnosis of Infectious Diseases	Antiretroviral drugs and resistance	Sterilization and disinfection	Immunodeficiency

Fever in travellers	Viral infections of the skin and mucosa		Approach to Outbreak investigation
Anaerobe infections	Viral infections in immunocompromised patients		Introduction to molecular biology and epidemiology
NTM and TB	VHF		Medical ethics of HIV and TB
Anti-TB drugs			Global trends in anti-microbial use
Microbes causing hospital acquired infections			Drug dosage
Prevention of spread of hospital acquired infection			Malaria prophylaxis
Approach and management of hospital acquired outbreaks			
Opportunistic infections			

APPENDIX 7

Turnitin Report

Impact of an infectious disease training module on the awareness regarding antimicrobial stewardship, infection prevention and control practices among third-year medical students in kwazulu-natal

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