Assessment of Competencies Relevant to Antimicrobial Resistance Prevention and One Health Among Undergraduate Medical Students: A Multinational Cross-Sectional Study

Study Focus: Competencies Relevant to Antimicrobial Resistance Prevention and One Health

• Abstract:

Background: Antimicrobial resistance (AMR) occurs when bacteria, viruses, fungi and parasites do not respond to antimicrobial medicines. It is a major global health threat requiring effective prevention and control across healthcare settings. Strengthening the competencies of future healthcare professionals through appropriate education and training is essential to addressing AMR within a One Health approach. However, existing evidence is predominantly focused on knowledge, attitudes, perceptions, practices, or specific aspects of antimicrobial use, rather than integrated competency assessment.

Objective: To assess the level of competencies relevant to AMR prevention and One Health among Undergraduate Medical Students and examine differences across academic levels and participating countries.

Methods: A multinational cross-sectional study will be conducted across seven countries (Benin, Sudan, Malawi, Botswana, Cameroon , Nigeria and Namibia), involving three universities in each country. The study will include Undergraduate Medical Students. A non-probability sampling approach will be used. Data will be collected using a structured online questionnaire that will be adapted using the Competencies for One Health field epidemiology (COHFE) framework as a reference for relevant One Health competencies and the WHO AMR competency framework as a reference for AMR-specific competencies. The instrument will undergo expert review and pilot testing before the main study. Competency levels and associated factors will be assessed using appropriate statistical methods.

Expected outcomes : The study is expected to identify One Health and AMR competency levels and competency gaps across participating disciplines and countries and to identify factors associated with competency levels.

Justification: Findings may inform competency-based One Health–AMR education, and support the preparation of future medical professionals for AMR prevention and control.

● **Keywords**:

Competency assessment , Antimicrobial stewardship, AMR education.

● **Background:**

Antimicrobial resistance (AMR) is a major global health and socioeconomic threat associated with more than 4.7 million deaths globally in 2021. occurring when microorganisms do not respond to antimicrobial medicines and driven largely by the misuse and overuse of antimicrobials. Strengthening the knowledge and

competencies of healthcare professionals through appropriate education and training is therefore essential for preventing and controlling AMR and promoting the responsible use of antimicrobials[1].

Several of the participating countries have documented action plans, for example Nigeria has implemented One health AMR National Action Plan (2024_2028) [2], Cameroon National Action Plan for the Fight Against Antimicrobial Resistance (2024_2028) [3], as well as national AMR action plan in 2025 in Botswana[4] . These plans emphasize key areas relevant to healthcare workforce preparedness, including antimicrobial stewardship, infection prevention and control, surveillance, education, training, and One Health collaboration. However the implementation varies considerably across settings, the effective implementation of these plans requires a health workforce prepared with appropriate AMR and One Health competencies. The WHO AMR competency framework provides a standardized, evidence-based reference for academic institutions, educators, regulators,

and other stakeholders to support the development of competencies required to prevent and control AMR [5] . It also provides guidance for developing locally adaptable curricula and educational resources that reflect national and contextual needs.

One Health is an integrated approach that recognizes the interdependence of human, animal, plant, and environmental health and promotes collaboration across sectors to address shared health and ecosystem threats. In the context of AMR, this approach is particularly important because antimicrobial use and resistance can emerge and spread across human, animal, and environmental interfaces [6] .The COHFE framework informs the broader One Health competency component [7], while the WHO AMR competency framework informs AMR-specific competency assessment . Their relevant elements are mapped and adapted to the context of undergraduate healthcare students.

The WHO Global Action Plan on AMR emphasizes the integration of AMR into professional education and training. In line with this priority, WHO has developed competency frameworks and curriculum guidance to support the acquisition of the knowledge and skills required to address AMR among healthcare students and professionals[8]. These frameworks provide a basis for assessing AMR-related competencies and understanding students' exposure to relevant educational content.

In the present study, students' previous exposure to AMR and One Health education will be assessed, with particular attention to whether relevant content has been encountered through formal university curricula or through other educational sources. This will provide insight into the educational context in which students develop competencies relevant to One Health and AMR prevention and control.

- **Problem Statement :**

Antimicrobial resistance (AMR) is a major global health and socioeconomic threat driven by interconnected factors across human, animal, and environmental systems, requiring healthcare professionals to develop both AMR-specific and One Health competencies. A systematic review conducted in the WHO African Region found that most published studies focused on knowledge, attitudes, and practices related to AMR and antimicrobial use [9]. Similarly, A cross-sectional survey was carried out among final year undergraduate medical and pharmacy students at three universities in East Africa identified gaps in practical training of students [10]. More recently a multicentre study assessed the knowledge of key one health elements, focused on general One Health knowledge rather than integrated competencies required for AMR prevention and control [11] .

Therefore, there is a need for a standardized, evidence-informed assessment of AMR-related One Health

competencies among future medical professionals across diverse African settings.

- **Justification / Significance of the Study:**

According to The Lancet global health study, The burden of bacterial antimicrobial resistance WHO African region in 2019, there were an estimated 1.05 million deaths associated with bacterial AMR and 250.000 deaths attributable to bacterial AMR [12]. This burden highlighted the need to ensure that future healthcare professionals are adequately prepared to contribute to AMR prevention and control.

Despite these global and national commitments, existing evidence has predominantly assessed AMR-related knowledge, attitudes, practices, or specific educational exposures. Evidence on integrated One Health–AMR competencies among undergraduate medical students across multiple African countries remains limited. This study therefore aims to assess these competencies, identify competency gaps, and examine variations

according to academic level, country, and previous educational exposure to AMR and One Health. Such evidence is needed to inform competency-based curricula and training approaches for future medical professionals.

- **General Objective:**

To assess the level of competencies relevant to Antimicrobial Resistance Prevention and One Health Among Medical Students.

- **Specific Objectives:**

1/ To identify specific gaps in competencies relevant to Antimicrobial Resistance prevention and One Health among undergraduate medical students.

2/ To compare competency levels across different academic levels and participating countries.

3/ To assess the association between students'reported previous exposure to AMR and One Health education and their competency levels.

4/ To assess the extent of students' reported exposure to relevant One Health and AMR competencies and their integration through formal university curricula and other educational sources.

- **Research Questions:**

Primary:

What is the level of Competencies relevant to Antimicrobial Resistance Prevention and One Health Among undergraduate medical sttudents?

Secondary:

1/ What are the specific gaps in competencies relevant to Antimicrobial Resistance prevention and One Health among undergraduate medical students?

2/ Do One Health competency levels differ across academic levels and participating countries?

3/ Is previous exposure to AMR and One Health education associated with One Health competency levels among students?

4/ What is the reported extent of students' reported exposure to relevant One Health and AMR competencies and their integration through formal university curricula and other educational sources.

- **Literature Review:**

A key approach to address the challenge of AMR and ensure the appropriate use of antimicrobials is to ensure that health workers acquire, through their education and training, the competencies required to prevent and combat AMR.

A study of David McMaster used a modified Delphi process involving experts from UK medical schools to establish consensus-based AMR and antimicrobial stewardship competencies for undergraduate medical students, a total of 58 consensus-based competency

descriptors within six overarching domains were identified [13], however, the study did not cover one health_AMR competency needs of students from different disciplines and nationalities. The COHFE framework, developed by FAO, WHO, and WOAH, provides a structured competency framework for One Health field epidemiology; its relevant elements require contextual selection and adaptation for undergraduate healthcare students. In addition, The WHO Competency Framework for Health Workers' Education and Training on AMR provides an important foundation for assessing AMR-related competencies among healthcare students .

A systematic review and meta-analysis was conducted in in Google Scholar, PubMed, and African Journals Online Library by WHO African Region according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline, Eighty-five published articles reporting 92 different studies from 19 Member States met inclusion criteria , the majority of the articles were on knowledge, attitude, and practices with regard to

AMR and antimicrobial use [14] . A multicentre study was conducted by Fatma A Amer (2025) targeted higher education students from diverse academic disciplines assessed One Health knowledge level in 26 African countries [11]

The present study will address the gap by assessing One Health competencies relevant to AMR prevention and control among undergraduate medical students across seven participating African countries. The study will adapt and synthesize self-administered questionnaire and use selected items mapped to competency domains informed by relevant WHO and COHFE frameworks and will examine competency levels, differences across academic levels, countries, and previous educational exposure to AMR and One Health.

- **Operational Definitions:**

One Health

It is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems.

It recognizes that the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and interdependent. [2]

Antimicrobial Resistance (AMR)

It occurs when bacteria, viruses, fungi and parasites do not respond to antimicrobial medicines. As a result, infections become difficult or impossible to treat, increasing the risk of disease spread, severe illness, disability and death.[1]

Competency

The measurable combination of relevant knowledge, skills, attitudes, and the ability to apply them appropriately in a specific professional or health context. In this study, competency will be assessed through structured competency items and case-based scenarios.

AMR Competencies

The measurable knowledge, skills, attitudes, and ability to apply relevant principles required to understand, prevent, and respond to antimicrobial resistance effectively.

One Health Competencies

The measurable knowledge, skills, behaviors, and attitudes that professionals must possess to collaborate effectively on complex health challenges at the animal-human-environment interface.

Integration of One Health into AMR

Competencies that involve applying One Health principles to the prevention and control of AMR, including recognition of the interconnectedness of AMR across human, animal, and environmental health and the ability to support coordinated action across relevant sectors.

Antimicrobial Stewardship

Is a systematic approach to educate and support health care professionals to follow evidence-based guidelines for

prescribing and administering antimicrobials. The education of the health workforce is of crucial importance, as they form the front line in safeguarding the effectiveness of antimicrobial medicines [15]

Infection Prevention and Control (IPC)

Is a practical, evidence-based approach preventing patients and health workers from being harmed by avoidable infections. Effective IPC requires constant action at all levels of the health system, including policymakers, facility managers, health workers and those who access health services [16]

Diagnostic Stewardship

Is coordinated guidance and interventions to improve appropriate use of microbiological diagnostics to guide therapeutic decisions. It should promote appropriate, timely diagnostic testing, including specimen collection, and pathogen identification and accurate, timely reporting of results to guide patient treatment.

Undergraduate Medical Students

Students enrolled in a medical school program who gain clinical experience through structured rotations, starting as junior medical students in their third year and progressing to senior medical students in their final year.

Competency Score

A numerical score derived from participants' responses to the competency assessment items. Domain-specific scores and an overall competency score will be calculated according to the scoring system established for the final study instrument.

Previous AMR/One Health Education

Any reported educational exposure to AMR, One Health, antimicrobial stewardship, infection prevention and control, diagnostic stewardship, surveillance, or related topics received before participation in the study through formal university curricula or other educational sources.

- **Study Design**

This study will adopt a cross-sectional multicentre, multinational design.

- **Study Setting / Study Area**

The study will be conducted across selected universities in seven African countries: Benin, Sudan, Malawi, Botswana, Cameroon,Namibia, and Nigeria.

- **Study Period:**

The study will be conducted over a period of approximately 3 months.

- **Study Population**

The study will include undergraduate medical students enrolled in participating universities.

- **Inclusion Criteria**

1- Are currently enrolled as undergraduate medical students at one of the participating institutions.

2- Are enrolled at one of the participating institutions during the study period.

3- Provide informed consent to participate.

- **Exclusion Criteria:**

1- Are not currently enrolled as undergraduate medical students at one of the participating institutions.

2- Are not enrolled at one of the participating institutions during the study period.

3- Do not provide informed consent.

- **Sample Size Determination:**

The final sample size will be determined in consultation with a statistician based on the primary outcome, planned comparisons across countries and disciplines, and anticipated non-response or incomplete data.

- **Sampling Technique:**

A non-probability sampling approach will be used to recruit eligible students from the participating universities and countries. Participants will be recruited through university and student networks and relevant academic platforms.

Snowball sampling may also be used where appropriate to facilitate recruitment and reach eligible participants. Recruitment will aim to achieve adequate representation across participating countries, and universities.

- **Variables of the Study:**

Dependent variables:

_ Overall competency score

_ Domain-specific competency scores

Independent variables:

_ Academic level

_ Country

_ University

_ Previous AMR educational exposure

_ Previous One Health educational exposure

_ Formal curricular exposure

_ Exposure to integrated One Health–AMR content

_ Relevant demographic variables

- **Data Collection Tools:**

Data will be collected using a structured, self-administered electronic questionnaire. The questionnaire will be adapted using the COHFE framework as a reference for relevant One Health competencies [7] and the WHO AMR competency framework as a reference for AMR-specific competencies[5] . Relevant competency domains will be operationalized into measurable questionnaire items appropriate to the participating medical student populations.

The questionnaire will cover demographic and academic characteristics, educational exposure to AMR and One Health, One Health–AMR competency domains, case based scenarios, participants' previous educational exposure, and reported extent of formal curricular exposure to relevant competencies.

The adapted instrument will undergo expert review and pilot testing to assess its relevance, clarity, and suitability for the target population before the main data collection.

- **Data Collection Procedure:**

Data will be collected using a standardized, self-administered online questionnaire adapted and synthesized from existing instruments and aligned with selected competency domains. The questionnaire will be administered through KoboToolbox.

Eligible participants will receive information about the study, including its objectives, voluntary nature, confidentiality, and expected completion time. Electronic informed consent will be obtained before participation.

Participants will be recruited through university and student networks and relevant academic platforms according to the predefined eligibility criteria. Recruitment will target undergraduate medical students across

participating countries. Snowball sampling may also be used where appropriate.

Participants will complete the questionnaire independently, and the same standardized procedures will be followed across participating sites.

- **Pilot Study:**

A pilot study will be conducted among a 10% group of total sample size, students will be similar to the target population and they will not be included in the final sample.

The pilot will assess the clarity, comprehensibility, feasibility, completion time, and technical functionality of the questionnaire. Necessary modifications will be made before the main data collection, and substantial changes will be documented.

- **Data Quality Control:**

Data quality will be monitored during and after data collection. Standardized eligibility criteria, questionnaire

procedures, and appropriate electronic validation rules will be applied across participating sites.

The dataset will be reviewed for incomplete responses, duplicate records, missing data, inconsistencies, and unusual values. Data cleaning and exclusion of records will follow predefined criteria and will be documented before analysis.

- **Data Management:**

Data will be stored in password-protected systems with access restricted to authorized research team members. The original dataset will be retained separately from the cleaned analytical dataset, and data-cleaning procedures will be documented.

No directly identifying information will be collected. Data will be handled according to approved ethical requirements and applicable data-protection regulations. A final review will be conducted before statistical analysis.

- **Data Analysis Plan:**

Data will be analyzed using appropriate statistical software. The dataset will be checked for completeness, duplicate responses, missing values, inconsistencies, and coding errors.

Participant characteristics will be summarized using appropriate descriptive statistics. Competency items will be scored according to a predefined scoring system, with domain-specific scores calculated for the six competency domains and an overall competency score calculated if supported by the final instrument structure and psychometric assessment.

Differences in competency scores across academic levels, countries, and educational exposures, including formal curricular exposure to AMR and One Health, will be examined using appropriate statistical tests. Where appropriate, multivariable regression analysis will be used to assess factors independently associated with competency levels.

Statistical significance will be assessed at $p < 0.05$, with effect estimates and 95% confidence intervals reported where appropriate

●Ethical Considerations :

Ethical approval will be obtained from the appropriate institutional or national research ethics committees before data collection.

● Expected Outcomes:

The study is expected to provide baseline evidence on One Health–AMR competency levels among undergraduate medical students across participating countries and disciplines. It is expected to identify key competency gaps and differences across academic levels, and countries, as well as factors associated with competency levels. The findings will provide a clearer understanding of the preparedness of future medical professionals for AMR prevention and control.

● Research Implications:

The findings of this study are expected to provide baseline evidence on the level of One Health competencies related to antimicrobial resistance (AMR) among medical students across participating countries. This is particularly relevant as these students represent the future medical workforce and will contribute to antimicrobial stewardship, infection prevention and control, diagnosis, surveillance, patient education, and other activities related to AMR prevention and control.

Previous multicentre evidence, by Amer et al. (2025) [11], among higher-education students across 26 African countries, has demonstrated variation in knowledge of key One Health elements across academic disciplines and countries. The present study will extend this evidence by focusing on One Health competencies relevant to AMR prevention and control, rather than knowledge alone. Comparing competency levels across academic levels, and countries may identify both common and context-specific competency gaps.

The study may identify gaps in areas such as AMR awareness, antimicrobial stewardship, infection prevention and control, diagnostic stewardship and surveillance, and interprofessional collaboration. The findings may inform the refinement or contextual adaptation of competency-based educational content for healthcare students. This is consistent with the consensus study (2020) [13], which highlighted the potential use of AMR competency descriptors to inform educational standards, curriculum design, teaching materials, and assessment approaches.

The findings may inform universities and health-training institutions in curriculum development or refinement and provide a basis for incorporating more practical, case-based, interprofessional, and experiential learning approaches. They may also support the development of interprofessional learning activities that strengthen communication, collaboration, and shared approaches to AMR prevention and control.

Finally, the multinational design may help distinguish common educational priorities from context-specific differences across participating settings. Overall, the study may contribute to strengthening the preparedness of the future healthcare workforce and provide evidence to guide educational, institutional, and broader One Health strategies for AMR prevention and control.

- **Limitations of the Study:**

The cross-sectional design will be one of the main limitations of this study. Since data will be collected at a single point in time, the study will allow assessment of One Health–AMR competency levels and identification of associations with factors such as year of study, and previous AMR training; however, causal relationships and temporal sequences cannot be established. For example, higher competency among senior students cannot be interpreted as evidence that progression through the curriculum caused the observed difference.

Selection bias may also occur because recruitment will primarily be conducted through online questionnaires and academic and student networks. Students with greater interest in AMR, One Health, or public health may be more likely to participate, potentially resulting in a sample that differs from the broader student population; this will be minimized through recruitment across multiple university-based channels, and neutral recruitment messages.

The use of self-administered and self-reported items may introduce information and social desirability bias, particularly for items concerning responsible antimicrobial use, infection prevention and control, and professional behaviour. Consequently, self-reported responses may not always accurately reflect participants' actual competencies or practices.

Differences in curricula and educational contexts across participating countries and universities may also influence the findings. Variation in the amount and type of AMR, One

Health, and infection prevention education may contribute to observed differences in competency levels, making it difficult to distinguish educational or institutional effects from country-level differences.

The adaptation of existing competency frameworks may present another limitation. The WHO AMR competency framework was developed within a specific professional and educational context, and some competencies may be more applicable to particular AMR-related professional roles than to undergraduate healthcare students. Therefore, not all competencies may be directly transferable to the study population. Framework mapping and expert review will be used to ensure the relevance and appropriateness of the selected competencies.

The generalizability of the findings may also be limited because participants will be recruited from selected institutions rather than through a nationally representative probability-based sampling strategy. Consequently, the findings may not be fully generalizable to all healthcare

students in the participating countries. Nevertheless, the multinational design will provide useful comparative evidence across the participating settings.

Finally, language and cultural differences may affect the interpretation and measurement of competencies across countries. Although standardized definitions, appropriate translation procedures and pilot testing will be used to address or minimize this issue, complete equivalence in the interpretation of questionnaire items across different languages, healthcare systems, and educational contexts may not always be achieved.

- **Strengths of the Study:**

Its multinational design will enable the assessment of One Health and AMR competencies across participating countries and among medical students, allowing comparison across different healthcare professions, academic levels, and educational contexts . The study also adopts an integrated One Health perspective and AMR specific competencies, with competency domains

informed by relevant WHO and COHFE frameworks, providing a structured guidance for the assessment.

Unlike studies focusing primarily on AMR-related knowledge, attitudes, or practices, this study will focus on competency assessment across multiple domains, providing a broader assessment of students' preparedness for their future professional roles. The study will also adapt existing questionnaires and assessment tools and align the selected items with the competency domains derived from the relevant frameworks . This approach combines existing evidence with a clearly defined theoretical foundation while avoiding the need to develop all assessment items de novo.

Furthermore, the adapted instrument will undergo expert review and pilot testing before the main data-collection phase to assess its clarity, relevance, comprehensiveness, and appropriateness for the target population. Finally, the study will enable comparison of competency levels across academic levels, participating countries, and relevant

educational exposures. This multidimensional approach may provide a more comprehensive understanding of One Health–AMR competency gaps and factors associated with competency levels among healthcare students.

- **Dissemination Plan:**

The findings will be disseminated through:

1/ Academic seminars and research meetings.

2/ Presentation through a national or international conference.

3/ Share the findings with the participating universities

4/ Share the findings with appropriate professional and academic networks.

- **Timeline / Work Plan / Giant chart:**

The final Timeline will be adjusted according to the progress and actual study period.

- **Budget:**

The final budget will be determined , including: internet, statistical analysis, ethical requirements fees.

- **Acknowledgments:**

The research team will acknowledge the participating universities, institutions, research advisors or collaborators.

- **References:**

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●**Appendices (Questionnaire):**

The questionnaire will be composed of sections covering: (1)participant demographic and academic characteristics, (2)previous educational exposure to AMR, antimicrobial stewardship, and One Health education and training,

(3)AMR Foundations & One Health Understanding, (4)Antimicrobial Stewardship & Appropriate Use, (5)Infection Prevention & Control, (6)Diagnostic Stewardship, Laboratory & Surveillance, (7)One Health Collaboration & Community Engagement, (8)Professional Responsibility, Ethics & Leadership, (9) Reported Curricular Exposure and Integration, (10) case-based scenarios to assess the application of knowledge and competencies in practical AMR-related situations.