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Original Article

Title: Antimicrobial Prescribing Confidence and Knowledge regarding Drug Resistance: Perception of Medical Students in Malaysia and the implications.

Short Title: Antimicrobial Prescribing Confidence and Antimicrobial Drug Resistance.

List of Authors

Mainul Haque [1], Tasim Ara [2], Md. Ahsanul Haq [3], Halyna Lugova [4], Siddhartha Dutta [5], Nandeeta Samad [6], Abdullahi Rabiu Abubakar [7], Sharifah Shasha Binti Syed Mohdhar [8], Md. Mahabubur Rahman [9], Salequl Islam [10], Nihad Adnan [11], Rahnuma Ahmad [12], Shahidah Leong Binti Abdullah [13], Mohd Hafizi bin Ismail [14], Brian Godman [15a, b, c]

1. Mainul Haque, Unit of Pharmacology, Faculty of Medicine and Defence Health, Universiti Pertahanan Nasional Malaysia (National Defence University of Malaysia), Kem Perdana Sungai Besi, 57000 Kuala Lumpur, Malaysia. Land Line: +60 3 9051 3400 Ext 2257 (Office). +60 3 6179 5871 (Home). Cell Phone: + 60 10 926 5543. **Email**: runurono@gmail.com. mainul@upnm.edu.my **Orcid ID**: https://orcid.org/0000-0002-6124-7993

2. Tasim Ara, Masters Student, Institute of Statistical Research and Training, University of Dhaka-1000, Bangladesh. **Email**: tara@isrt.ac.bd **Orcid ID**: https://orcid.org/0000-0003-4259-5113

3. Md. Ahsanul Haq, Gonoshasthaya-RNA Molecular Diagnostic & Research Center, Dhanmondi, Dhaka-1205, Bangladesh. **Email**: ahsan@rnabiotech.com.bd **Orcid ID**: https://orcid.org/0000-0002-4408-6104

4. Halyna Lugova, Associate Professor and Head of Community Medicine, Faculty of Medicine and Defence Health, National Defence University of Malaysia. **Email**: halina@upnm.edu.my **Orcid ID**: https://orcid.org/0000-0001-8052-0580

5. Siddhartha Dutta, Senior Resident, Department of Pharmacology, All India Institute of Medical Sciences, Jodhpur, Rajasthan, India. **Email**: siddhartha.dutta87@gmail.com **Orcid ID**: https://orcid.org/0000-0001-6525-5950

6. Nandeeta Samad, Lecturer, Department of Public Health, North South University, Bangladesh. **Email**: Nandeeta.samad@northsouth.edu **Orcid ID**: https://orcid.org/0000-0002-3623-0743

7. Abdullahi Rabiu Abubakar, Lecturer, Department of Pharmacology and Therapeutics, Faculty of Pharmaceutical Sciences, Bayero University, Kano. Postcode: 700233. PMB., 3452, Kano, Nigeria. **Email**: unisza7@gmail.com **Orcid ID**: https://orcid.org/0000-0002-9740-7856

8. Sharifah Shasha Binti Syed Mohdhar, Medical Student, Faculty of Medicine and Defence Health, Universiti Pertahanan Nasional Malaysia (National Defence University of Malaysia), Kem Perdana Sungai Besi, 57000 Kuala Lumpur, Malaysia. **Email**: shashamohdhar@gmail.com **Orcid ID**: https://orcid.org/0000-0002-2478-3244

9. Md. Mahabubur Rahman, Masters Student, Institute of Statistical Research and Training, University of Dhaka-1000, Bangladesh. **Email**: mrahman4@isrt.ac.bd **Orcid ID**: https://orcid.org/0000-0002-3283-5163

10. Salequl Islam, Professor, Department of Microbiology, Jahangirnagar University, Savar, Dhaka-1342, Bangladesh. Email: salequl@gmail.com. **Orcid ID**: https://orcid.org/0000-0001-6131-4132

11. Nihad Adnan, Associate Professor, Department of Microbiology, Jahangirnagar University, Savar, Dhaka-1342, Bangladesh. **Email**: nihad@juniv.edu, **Orcid ID**: https://orcid.org/0000-0002-4999-4793

12. Rahnuma Ahmad. Assistant Professor, Department of Physiology, Medical College for 8 Women and Hospital, Dhaka, Bangladesh. Email: rahnuma.ahmad@gmail.com, **Orcid ID**: https://orcid.org/0000-0001-7379-0822

13. Shahidah Leong Binti Abdullah, Clinical Psychologist. Faculty of Medicine and Defence Health, Universiti Pertahanan Nasional Malaysia (National Defence University of Malaysia), Kem Perdana Sungai Besi, 57000 Kuala Lumpur, Malaysia. **Email**: shahidah2013@gmail.com **Orcid ID**: https://orcid.org/0000-0002-9296-1946

14. Mohd Hafizi Bin Ismail, Senior Assistant Registrar. Faculty of Medicine and Defence Health, Universiti Pertahanan Nasional Malaysia (National Defence University of Malaysia), Kem Perdana Sungai Besi, 57000 Kuala Lumpur, Malaysia. **Email**: hafizi@upnm.edu.my **Orcid ID**: https://orcid.org/0000-0002-7745-9413

15. [a] Division of Public Health Pharmacy and Management, School of Pharmacy, Sefako Makgatho Health Sciences University South Africa; [b] Department of Pharmacoepidemiology, Strathclyde Institute of Pharmacy and Biomedical Sciences, University of Strathclyde, Glasgow, UK, and [c] Centre of Medical and Bio-allied Health Sciences Research, Ajman University, Ajman, United Arab Emirates. **Email**: brian.godman@strath.ac.uk **Orcid ID**: https://orcid.org/0000-0001-6539-6972

Address of Correspondence

Mainul Haque. Professor of the Unit of Pharmacology, Faculty of Medicine and Defence Health, Universiti Pertahanan Nasional Malaysia (National Defence University of Malaysia), Kem Perdana Sungai Besi, 57000 Kuala Lumpur, Malaysia. Cell Phone: + 60 10 926 5543. **Email**: runurono@gmail.com mainul@upnm.edu.my **Orcid ID**: https://orcid.org/0000-0002-6124-7993

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Original Article

Title: Antimicrobial Prescribing Confidence and Knowledge regarding Drug Resistance: Perception of Medical Students in Malaysia and the implications.

Short Title: Antimicrobial Prescribing Confidence and Antimicrobial Drug Resistance.

Abstract

Background: Worldwide, microbes are becoming more dangerous by acquiring virulent skills to adapt and develop antimicrobial resistance (AMR). This is a concern as this increases morbidity, mortality, and costs. Consequently, physicians need to be trained inappropriate prescribing, starting with medical students.

Objective: Evaluate medical students' confidence in antimicrobial agent prescribing and drug resistance

Methods: Cross-sectional study assessing medical students' knowledge, perception, and confidence in prescribing antimicrobial agents and drug resistance in a Malaysian University. A universal sampling method was used.

Results: Most respondents believe that educational input regarding overall prescribing was sufficient. Regarding the principle of appropriate and accurate prescriptions, female medical students had less knowledge [Odds Ratio (OR)=0.51; 95% Confidence Interval (CI) 0.25-0.99; p=0.050]. Year-IV and Year-V students had more excellent knowledge than Year-III students regarding confidence in antibiotic prescribing. Year-V students also showed appreciably higher confidence in the broad principles of prescribing, including infectious diseases, compared to those in other years.

Conclusion: Overall, medical students, gain more excellent knowledge and confidence regarding prescribing, including antimicrobials, as their academic careers progress.

Keywords: Antimicrobial, Prescribing, Drug Resistance, Knowledge, Perception, Medical Students, Malaysia

1. Introduction

Microorganisms, including bacteria, viruses, fungi, and other parasites, have increasingly adapted and become accustomed to the presence of antimicrobials that were once lethal, leading to antimicrobial resistance (AMR) [1,2]. Additionally, drug resistome is a vigorous and escalating public-health concern [3]. The resistome can be described as an entity encompassing all the antimicrobial resistance genes and contains resistance genetic components found equally among pathogens and antimicrobial-producing microbes, with enigmatic resistance

genes present in microbial chromosomes [4]. Increasing AMR, fueled by excessive and inappropriate use of antimicrobials [5-8], is a concern as this increases morbidity, mortality, and costs [9-11]. The World Bank believes annual worldwide GDP would decrease by 1.1% in the low-impact AMR scenario and 3.8% in the high-impact AMR scenario and may cross over 5% by 2050. Additionally, the cost possibly will increase from $300 billion to more than $1 trillion per year by 2050 [12]. Other factors increasing AMR include overpopulation, excessive self-purchasing of antibiotics without a prescription for self-limiting conditions, traveling, water pollution, and lack of hygiene and water sanitation [3, 13-16].

There is an urgent need for coordinated approaches to combat rising AMR rates, especially among low- and middle-income countries (LMICs), including improved antimicrobial stewardship programs (ASPs) [17-19]. Microbes do not require any passport to cross geographical borders, with resistant microbes affecting high-income countries (HICs) and (LMICs) although more significant in LMICs. This led to global and national action plans to reduce AMR coordinated by the WHO and others [19-21].

Improving student knowledge regarding antibiotics and AMR are prudent ways to improve prudent prescribing of antibiotics in ambulatory care following graduation, achieved through ASPs and other programs [22-25]. Comprehensive understanding of the pathophysiology of diseases and clinical pharmacology and therapeutics are also indispensable for prudent prescribing along with quality targets [26-28]. Moreover, any healthcare professionals' (HCP) purpose of treating a patient should be documented on paper and duly signed, ideally in line with current prescribing guidance [28].

In both public and private primary health care settings in Malaysia and emergency departments, antimicrobials are often prescribed for self-recovering diseases, including upper respiratory tract infections (URTIs) [29-33]. However, this was more noticed in the private health care system, potentially enhanced by financial considerations and more significant patient pressures [29]. Long waiting times to see HCPs in Primary Healthcare Clinics (PHCs) in Malaysia and more expansive further adds to the pressure on HCPs to prescribe antimicrobials rather than spend valuable time providing an explanation why they are reluctant to prescribe [10, 25, 30, 31, 34-37]. This is a concern given rising AMR rates in Malaysia [38-43]. HCPs, including physicians, are a key stakeholder group to target as they can appreciably influence antimicrobial utilization in Malaysia. This is similar to LMICs, with prescribing a significant activity among ambulatory care physicians [44]. Encouragingly, multiple interventions, including educational interventions, can reduce inappropriate prescribing of antibiotics for essentially viral infections, including URTIs among physicians in LMICs[10, 25, 45]. This should be borne in mind during undergraduate teaching and followed-up post qualification.

However, it has been reported that Malaysian university students, including medical students, often take antimicrobials without any prescription [46]. This concern with inappropriate dispensing of antibiotics without a prescription appreciably adds to growing AMR rates [10, 25, 47]. This is despite university students in Malaysia knowing that self-medication of antimicrobials is unwise [46]. Earlier studies also showed that whilst medical students possess sound knowledge about prescribing, including antimicrobials, they felt a gap between theoretical and practical clinical pharmacology input. In so doing, suggested additional teaching-learning hours regarding prescribing skills, including antimicrobials [48. 49]. This is because inadequate knowledge can enhance irrational prescribing post-qualification, which is challenging to repair. Consequently, it is better to intervene before imprudent prescribing develops during student-ship before graduation [48. 49], rather than wait post-qualification when poor prescribing habits have become ingrained.

Consequently, we wanted to build on these earlier findings in Malaysia to provide future guidance on the curriculum for medical students going forward. Because of this, this study sought to determine Malaysian medical students' self-confidence and knowledge over their clinical years in managing infectious diseases and prudent antimicrobial prescribing and correlating this with infectious diseases' proficiency. This study also sought to assess the relative effectiveness of various instruction/teaching delivery modes in gaining and retaining knowledge of medicines and prescribing, including antimicrobial prescribing. The combined findings can help improve physician education in Malaysia and broader in the future with increasing challenges from viral and other diseases.

2. Materials and Methods

2.1. **Study Design**: A cross-sectional study was undertaken to assess the clinical years' medical students' knowledge and perception of prescribing antimicrobial agents and AMR. A survey questionnaire was employed as a data collection tool among Year III-V medical students.

2.2. **Study Population**: The study population was the clinical year's medical students of the Faculty of Medicine and Defence Health, Universiti Pertahanan Nasional Malaysia [(UPNM) the National Defence University of Malaysia], Kem Perdana Sungai Besi, Kuala Lumpur, Malaysia. This study comprises three ethnic groups: Malay, Chinese, and Indian. There are currently three categories of medical students admitted to UPNM. Those are Cadet Officers, Territorial Army, and Civilians.

2.3. **Study Period**: The data collection exercise was carried out from January 7, 2018, to March 21, 2019, i.e., before starting the COVID-19 pandemic with its restrictions on University education. Year-III clinical students were initially unavailable on campus during the initial data

collection period. Similarly, other students were away at various times for clinical activities necessitating an extended period for data collection.

2.4. **Sampling Method and Sample Size**: The survey was conducted using a universal sampling method comprised of all Year III, IV, and V medical students from 2018 to 2019 academic sessions. The research group distributed 155 study instruments among clinical Year-III, IV, and V students during the principal study, and 15 were dispersed during the pre-tested phase. A total of 170 study instruments were distributed.

2.5. **Data Collection Tool (Questionnaire)**:

The data was collected using a validated questionnaire on antimicrobial prescribing knowledge, and perception was used based on a previous study conducted by Weier et al. (2017) [51]. The study instrument was subsequently pre-tested and validated for the local context in Malaysia. Five medical students of each clinical year (5X3=15) participated in the questionnaire validation process. They did not participate in the principal study.

Survey Reliability

Reliability analysis of the survey tool was undertaken. The Cronbach's alpha obtained was 0.9 for questions relating to the sufficiency of education, confidence in knowledge in different subject areas, confidence in various clinical situations, and perceptions of antimicrobial resistance.

The questionnaire comprised six (6) sections, A to F: Section A: Demographic information; Section B: Sufficiency of education and confidence in the knowledge; Section C: Modes of teaching and confidence in clinical situations; Section D: Perceptions of antimicrobial resistance; Section E: Knowledge of prescribing guidelines; Section F: Demonstration of clinical knowledge,

2.6. **Ethical Approval**: This research was reviewed and approved by the Institutional Research Ethical Committee from the Centre for Research, Innovation and management, National Defense University, Malaysia. Code: UPNM/2019/SF/SKK/04. Reference Number: UPNP (PPPI) 16.01/06/024 (2), Dated January 3, 2019. The participation of this study was completely voluntary and anonymous. Before distributing the instrument, the research respondents clearly explained the aim, scope, and future scientific paper issue before every data collection occasion. The printed information sheet was also provided to each student to learn more about the study. Additionally, researchers obtained written consent (approval) before research respondents participated in the pre-test and the principal research.

2.7 **Data Analysis**: The data were entered into an Excel file, which was then transferred into SPSS-22 software (IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.) and with Stata 15 (StataCorp, LP, College Station, Texas, USA) for further analysis and the graphs were prepared by GraphPad prism 8.3.0. The significance level was established at $p \leq 0.05$. Pearson's chi-square tests were used to determine the relationship between confidence level in infectious disease knowledge and other variables. The logistic regression model was introduced to explore the predictors of a confident group. Initially, the univariate logistic regression technique analyzed the relationship between several predictors and confidence levels in infectious diseases. Exploratory variables, gender, years of student, ethnicity, and designation in infectious diseases were regressed onto the confidence in infectious diseases as a response variable. An odds ratio (OR) greater or less than 1 indicated a greater probability or lower probability of being confident in the knowledge of infectious diseases compared to the reference category. Confidence in antibiotic prescribing and knowledge and attitude towards antibiotic resistance score difference among explanatory variables were assessed by independent sample t-test.

3. Results

The demographic distribution of the clinical students is contained in Table 1. Among the enrolled students, 47.1% and 52.9% were male and female, respectively. Out of the 140 research respondents, 47.9% were 22 years of age, and 68.6% were Malays. There were 47.9%, 39.3%, and 12.9% civilians, cadet officers' students, and the territorial army., respectively. This research respondent was Year III, IV, and V. The response rate was 90.32%. The total study population was 170 [15 (Pre-test) + 140 (Principal Study) + 5 (Discarded Because Incomplete Data) + 10 (Study Instrument were not returned)].

Table 1: Demographic distribution of the Data.

Variables		Response (n=140)
Gender		
	Male	66(47.14%)
	Female	74(52.86%)
Age category		
	21 years	40(28.57%)
	22 years	67(47.86%)
	23-24 years	33(23.57%)
Race		
	Malay	96(68.57%)
	Chinese	13(9.29%)
	Indian	31(22.14%)

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Designation		
	Civilian	67(47.85%)
	Cadet	55(39.29%)
	Territorial Army	18(12.86%)

NB: Data were presented with the number and with the percentage in parenthesis

4.3 Sufficiency in The Level of Education and Confidence in Knowledge regarding Prescribing Among Students

The majority of the clinical medical students (male=49.2% and female=50.9%) felt that their teaching-learning was sufficient for commonly prescribed drugs (**Table 2**). Similarly, the UPNM medical students (male=52.7% and female=47.8%) agreed that sufficient formal education and training is provided regarding appropriate and accurate prescription writing principles. Correspondingly male=48.8% and female=51.2% believed their formal education, training, and pharmacological confidence was sufficient (**Table 2**). Overall, half of the respondents generally agreed that all four-section [i. Commonly prescribed drug. ii. Principles of appropriate and accurate prescription writing; iii. Infectious diseases] sufficient educational input was given. However, there were statistically significant differences (**Table 2**) between sexes in appropriate and accurate prescription writing (p=0.050). Nevertheless, most medical students had confidence in their knowledge level regarding these issues.

Regarding the principles of appropriate and accurate prescription writing, female medical students showed less knowledge [Odds Ratio (OR)=0.51; 95% Confidence Interval (CI) 0.25-0.99; p=0.050] compared to males (**Table 2** and **Figure 1**). Year-V had an 8.0 times higher knowledge level (95% CI 1.05-67.4; p=0.049) than Year-III students (**Table 3**. All three ethnic groups were overall satisfied regarding their educational input, commonly prescribed drugs (80.2%), principles of appropriate and accurate prescription writing (64.6%), and infectious diseases (89.6%). No statistically significant difference was observed among the ethnic groups in four-component of the formal education and training on pharmacology (**Table 4**).

Table 2: Frequency and odds of gender in the formal education and training sufficiency and confidence on Pharmacology

	Male (n=66)	Female (n=74)	OR (95% CI)	p-value
Commonly prescribed drug				
Not sufficient	8(36.4%)	14(63.6%)	Ref.	
Sufficient	58(49.2%)	60(50.9%)	0.59(0.23, 1.51)	0.273

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Principles of appropriate and accurate prescription writing					
	Not sufficient	17(36.2%)	30(63.8%)	Ref.	
	Sufficient	49(52.7%)	44(47.8%)	0.51(0.25, 0.99)	0.050
Infectious diseases					
	Not sufficient	6(35.3%)	11(64.7%)	Ref.	
	Sufficient	60(48.8%)	63(51.2%)	0.56(0.20, 1.65)	0.301

NB: Data were presented as the number with the percentage in parenthesis and the odds ratio with a 95% confidence interval. Logistic regression was used to estimate the p-value.

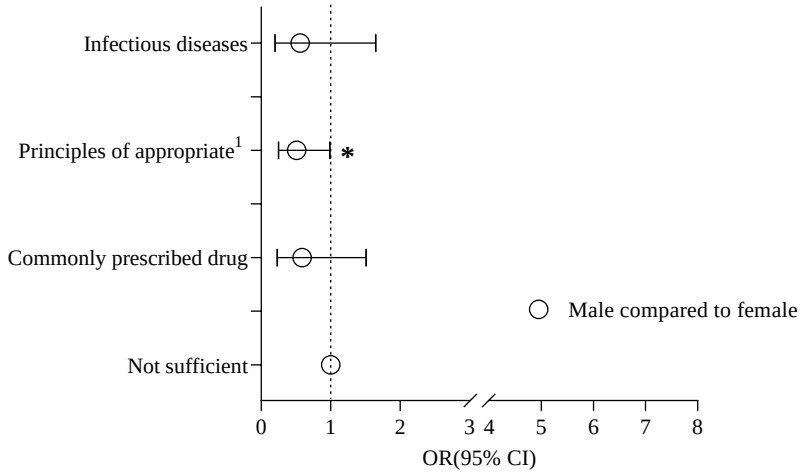

Figure 1: Odds of gender in the formal education and training on Pharmacology. **Note**:*p<0.05

Table 3: Frequency and odds of different year student in the formal education and training sufficiency and confidence on Pharmacology

	Y-III	Y-IV	Y-V	Y-III	Y-IV	Y-V	
Commonly prescribed drug							
Not sufficient	8(36.4%)	13(59.1%)	1(4.55%)	Ref.	Ref.	Ref.	
Sufficient	32(80.0%)	54(80.6%)	32(97%)	Ref.	1.04(0.39, 1.77)	8.0(1.05, 67.4)	0.049
Principles of appropriate and accurate							

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prescription writing						
Not sufficient	17(36.2%)	21(31.3%)	9(19.2%)	Ref.	Ref.	Ref.
Sufficient	23(25.6%)	46(68.7%)	24(26.7%)		1.62(0.72, 3.63)	1.97(0.73, 5.31)
Infectious diseases						
Not sufficient	6(15.0%)	10(14.9%)	1(3.00%)	Ref.	Ref.	Ref.
Sufficient	34(85.0%)	57(85.1%)	32(97.0%)		1.01(0.34, 3.00)	5.64(0.64, 49.4)

NB: Data have presented as the number with the percent in parenthesis and the odds ratio with a 95% confidence interval. Logistic regression was used to estimate the p-value. Y=Year

Table 4: Frequency and odds of ethnicity in the formal education and training sufficiency and confidence on Pharmacology

	Malay	Chinese	Indian	Malay	Chinese	Indian
Commonly prescribed drug						
Not sufficient	19(19.8%)	0	3(9.68%)	Ref.	Ref.	Ref
Sufficient	77(80.2%)	13(100%)	28(90.3%)		-	2.32(0.63, 8.41) (0.206)
Principles of appropriate and accurate prescription writing						
Not sufficient	34(35.4%)	1(7.69%)	12(38.7%)	Ref.	Ref.	Ref
Sufficient	62(64.6%)	12(92.3%)	19(61.3%)		6.55(0.82, 19.5) (0.076)	0.90(0.63, 1.99) (0.740)
Infectious diseases						
Not sufficient	10(10.4%)	3(23.1%)	4(12.9%)	Ref.	Ref.	Ref
Sufficient	86(89.6%)	10(76.9%)	27(87.1%)		0.39(0.09, 1.65) (0.199)	0.79(0.23, 2.72) (0.701)

NB: Data were presented as the number with percent in parenthesis and the odds ratio with a 95% confidence interval. Logistic regression was used to estimate the p-value

4.4 Modes of Teaching and Confidence in Clinical Situations

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Both male and female medical students believed that all five modes of teaching, i.e., lectures (89.4%), tutorials/ workshops/ problem-based learning (PBL) sessions (90.9%), clinical rotations (98.5%), informal education by fellow residents, and registrars (87.9%), and attending patient care rounds/ clerking / ward rounds (97.0%) were helpful or effective in attaining and improving knowledge about medicine and prescribing (**Table 5**). There were no statistically significant differences in the mode of teaching and knowledge and prescribing; including antimicrobials. Additionally, there were no statistically significant differences among the genders and the study years concerning ways of instruction. Year-III, Year-IV, and Year-V medical students were generally satisfied and valued all five different instructional methods (**Table 6**).

Table 5: Frequency and odds of gender in the relative effectiveness of various modes of delivery education instruction in gaining and retaining the knowledge of medicines and prescribing, including but not limited to antibiotics prescribing.

	Male (n=66)	Female (n=74)	Male	Female
Lectures				
Least useful	7(10.6%)	8(10.8%)	Ref.	Ref.
Useful	59(89.4%)	66(89.2%)		0.98(0.34, 2.86) (0.969)
Tutorials or workshops or PBL sessions				
Least useful	6(9.09%)	9(12.2%)	Ref.	Ref.
Useful	60(90.9%)	65(87.8%)		0.72(0.24, 2.16) (0.559)
Clinical rotations				
Least useful	1(1.52)	2(2.70%)	Ref.	Ref.
Useful	65(98.5%)	72(97.3%)		-
Informal teaching by fellow residents and registrars				
Least useful	8(12.1%)	4(5.41%)	Ref.	Ref.
Useful	58(87.9%)	70(94.6%)		2.41(0.69, 8.50) (0.167)
Attending patient care rounds/ward rounds				
Least useful	2(3.0%)	4(5.41%)	Ref.	Ref.
Useful	64(97.0%)	70(95.6%)		0.55(0.10, 3.10) (0.494)

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NB: Data were presented as the number with the percentage in parenthesis and the odds ratio with a 95% confidence interval. Logistic regression was used to estimate the p-value. PBL = Problem-Based learning

Table 6: Frequency and odds of student years in the relative effectiveness of various instructional modes in gaining and retaining the knowledge of medicines and prescribing, including but not limited to antibiotics prescribing (No significant difference was noted).

	Year-III	Year-IV	Year-V	Year-III	Year-IV	Year-V
Lectures						
Least useful	2(5.0%)	11(16.4%)	2(6.06%)	Ref.	Ref.	Ref.
Useful	38(95.0%)	56(83.6%)	31(93.9%)		0.27(0.06, 0.79) (0.098)	0.82(0.11, 6.11) (0.843)
Tutorials or workshops of PBL sessions						
Least useful	2(5.0%)	13(19.4%)	0	Ref.	Ref.	Ref.
Useful	38(95.0%)	54(80.6%)	33(100%)		4.57(0.97, 21.3) (0.054)	-
Clinical rotations						
Least useful	0	2(2.99%)	1(3.00%)	Ref.	Ref.	Ref.
Useful	40(100.0%)	65(97.0%)	32(97.0%)		-	-
Informal teaching by fellow residents and registrars						
Least useful	2(5.0%)	5(7.46%)	5(15.2%)	Ref.	Ref.	Ref.
Useful	38(95.0%)	62(92.5%)	28(84.9%)		-	-
Attending patient care rounds/ward rounds						
Least useful	1(2.50%)	4(5.97%)	1(3.00%)	Ref.	Ref.	Ref.
Useful	39(97.5%)	63(94.0%)	32(97.0%)		-	-

NB: Data have presented as the number with the percent in parenthesis and the odds ratio with a 95% confidence interval. Logistic regression was used to estimate the p-value.

Furthermore, among all three ethnic origins, the majority (84%) stated their trust, usefulness, and satisfaction regarding the five different teaching methods.

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Table 7: Frequency and odds of student years in the relative effectiveness of various delivery modes in gaining and retaining the knowledge of medicines and prescribing, including but not limited to antibiotics prescribing.

		Malay	Chinese	Indian
Lectures				
	Least useful	9(9.38%)	1(7.69%)	5(16.1%)
	Useful	87(90.6%)	12(92.3%)	26(83.9%)
Tutorials or workshops of PBL sessions				
	Least useful	9(9.38%)	1(7.69%)	5(16.1%)
	Useful	87(90.6%)	12(92.3%)	26(83.9%)
Clinical rotations				
	Least useful	1(1.04%)	2(15.4%)	0
	Useful	95(99.0%)	11(84.6%)	31(100%)
Informal teaching by fellow residents and registrars				
	Least useful	7(7.29%)	2(15.4%)	3(9.68%)
	Useful	89(92.7%)	11(84.6%)	28(90.3%)
Attending patient care rounds/ward rounds				
	Least useful	3(3.135)	2(15.4%)	1(3.23%)
	Useful	93(96.9%)	11(84.6%)	30(96.8%)

NB: Data were presented as the percentage number in the parenthesis.

4.5 **Confidence in Antimicrobial Prescribing**

In every aspect of confidence in antibiotic prescribing, Year-IV and Year-V students had higher knowledge than Year-III students. Additionally, Year-V students had significantly more knowledge than Year-IV students (**Figure 2**).

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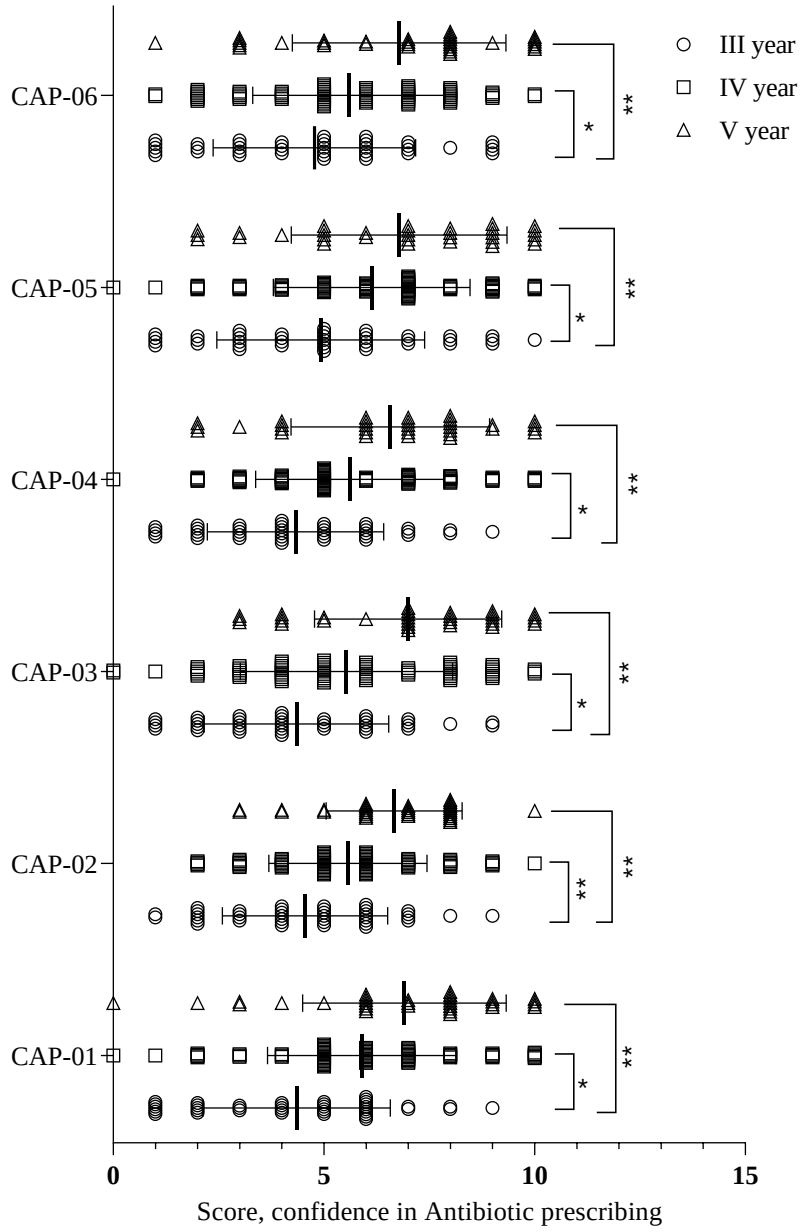

Figure 2: Mean difference of confidence in antibiotic prescribing (CAP) among students of different years.

Note: **p=0.002-0.09 and *p<0.05. CAP-01: Accurately diagnosing Community-Acquired Pneumonia; CAP-02: Accurately interpreting pathology and microbiology results; CAP-03: Knowing the right regimen [dose, frequency, and route of administration] for the antibiotic treatment for a specific indication such as Pneumonia or an exacerbation of COPD; CAP-04: Knowing the right duration for antibiotic treatment for a specific indication such as Pneumonia or an exacerbation of COPD; CAP-05: Identifying situations where antibiotic treatment is not necessary; CAP-06: Knowing when antibiotic treatment needs to be adjusted, stopped, or other treatments need to be used.

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4.6 Comparative Confidence in Antimicrobial Prescribing

The Year-III and Year-IV students showed the same confidence level in all four components (pharmacology knowledge, principles in prescribing, and infectious diseases). Year-V students showed 4-, 5.6-, and 5.9-times higher confidence than Year-III students in knowledge regarding the principals in prescribing (95% CI 1.51-11.02; p=0.006), prescribing knowledge for infectious diseases (95% CI 1.95-22.2; p=0.002) (**Table 8** and **Figure 3**). Malay and Chinese students showed the same levels of confidence; however, Indian students had more knowledge and confidence in knowledge regarding pharmacology (OR=1.72; 95% CI 1,17-6.23; p=0.019) and infectious diseases (OR=3.42; 95% CI 1.21-9.68; p=0.021) (**Table 9** and **Figure 4**). Prescribing confidence in different clinical situations is depicted in **Figure 5**.

Table 8: Frequency and odds of student years in confidence in prescribing knowledge.

	Y-III	Y-IV	Y-V	Y-III	Y-IV	Y-V
Pharmacology						
Somewhat confident	22(55.0%)	42(63.6%)	14(42.4%)	Ref.	Ref.	Ref.
Confident	18(45.0%)	24(36.4%)	19(57.6%)		0.57(0.31, 1.55)	1.67(0.66, 4.22)
Principles of prescribing						
Somewhat confident	30(75.0%)	48(71.6%)	14(42.4%)	Ref.	Ref.	Ref.
Confident	10(25.0%)	19(28.4%)	19(57.6%)		1.19(0.49, 2.89)	4.06(1.51, 11.02) (0.006)
Infectious diseases						
Somewhat confident	19(47.5%)	27(40.3%)	4(12.1%)	Ref.	Ref.	Ref.
Confident	21(52.5%)	40(59.7%)	29(87.9%)		1.34(0.61, 2.94)	5.55(1.95, 22.2) (0.002)

NB: Data were presented as the percentage number in the parenthesis and the odds ratio with a 95% confidence interval. Logistic regression was used to estimate the p-value

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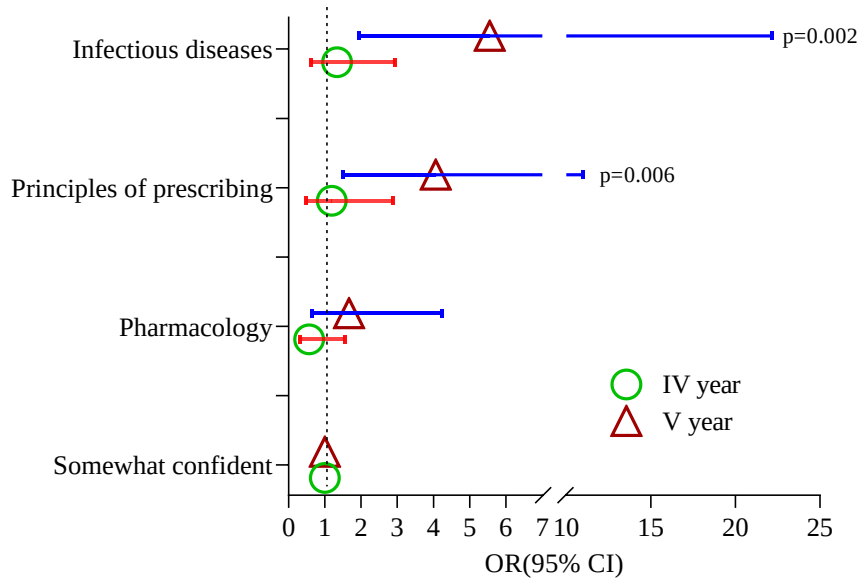

Figure 3: Odds of confidence in knowledge among the Year-IV and Year-V medical students compared to Year-III.

Table 9: Frequency and odds of Race/Ethnicity in the comparative confidence in knowledge.

	Malay	Chinese	Indian	Malay	Chinese	Indian
Pharmacology						
Somewhat confident	60(63.2%)	6(46.2%)	12(38.7%)	Ref.	Ref.	Ref.
Confident	35(36.8%)	7(53.9%)	19(61.3%)		1.99(0.63, 6.42)	1.72(1.17, 6.23) (0.019)
Principles of prescribing						
Somewhat confident	66(68.8%)	7(53.9%)	19(61.3%)	Ref.	Ref.	Ref.
Confident	30(31.3%)	6(46.2%)	12(38.7%)		1.88(0.58, 6.11)	1.39(0.60, 6.23)
Infectious diseases						
Somewhat confident	38(39.6%)	7(53.9%)	5(16.1%)	Ref.	Ref.	Ref.
Confident	58(60.4%)	6(46.2%)	26(83.9%)		0.56(0.18, 1.80)	3.42(1.21, 9.68) (0.021)

NB: Data have presented as the number with the percent in parenthesis and the odds ratio with a 95% confidence interval. Logistic regression was used to estimate the p-value

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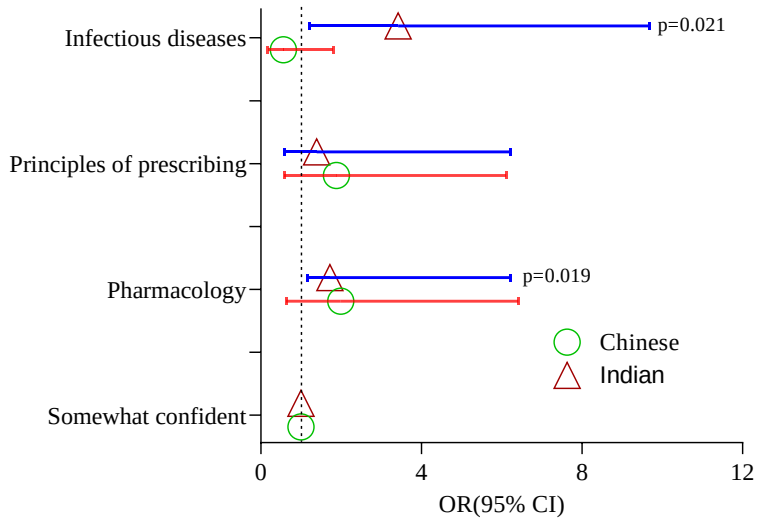

Figure 4: Odds of confidence in knowledge among the Chinese and Indian students compared to Malay students.

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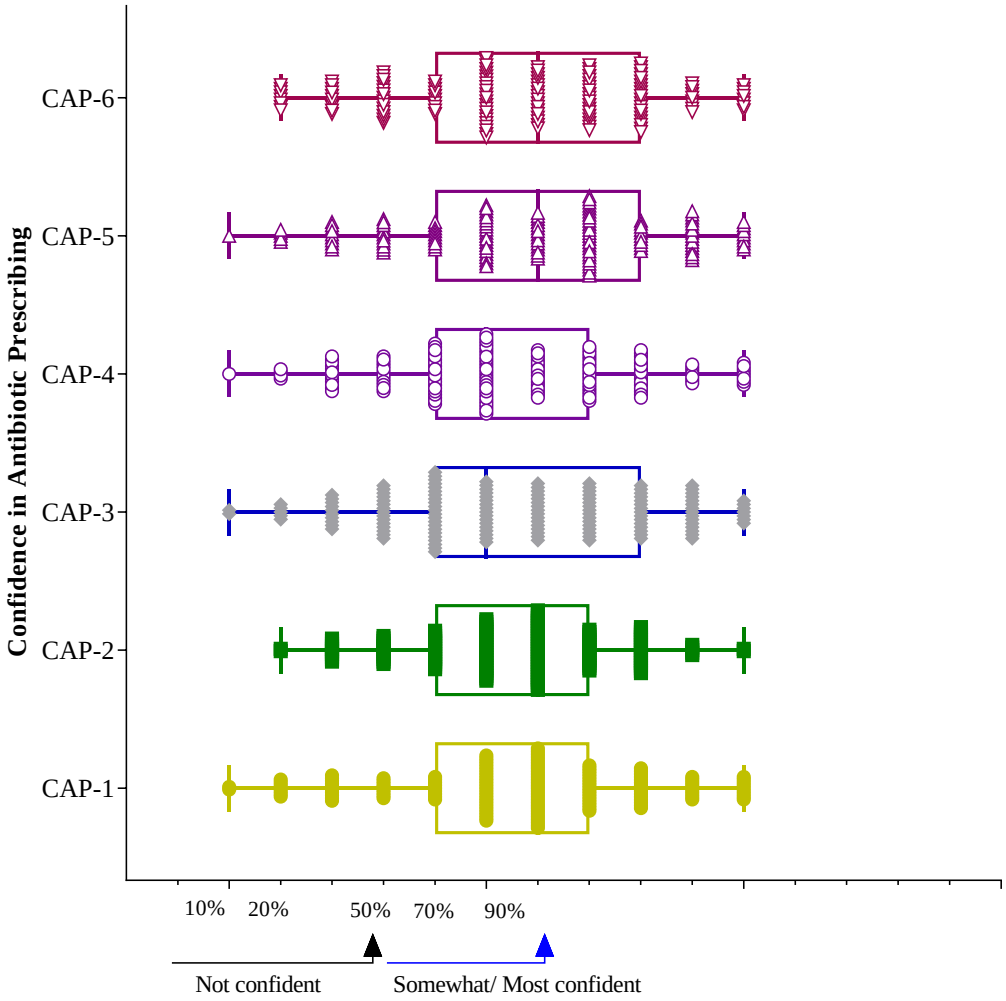

Figure 5: Confidence in Knowledge in Different Clinical Situations.
Note: CAP-01: Accurately diagnosing Community-Acquired Pneumonia; CAP-02: Accurately interpreting pathology and microbiology results; CAP-03: Knowing the proper regimen [dose, frequency, and route of administration] for the antibiotic treatment for a specific indication such as Pneumonia or an exacerbation of COPD; CAP-04: Knowing the suitable duration for antibiotic therapy for a particular indication such as Pneumonia or a worsening of COPD; CAP-05: Identifying situations where antibiotic treatment is not necessary; CAP-06: Knowing when antibiotic treatment needs to be adjusted, stopped, or other treatments need to be used.

4.7 Knowledge and Attitude Toward Antimicrobial Resistance

Almost all knowledge and attitude towards AMR scores were lower among Year-III students than Year-IV and V students (**Figure 6**). The perceptions of medical students on the different factors regarding AMR are illustrated in **Figure 7**.

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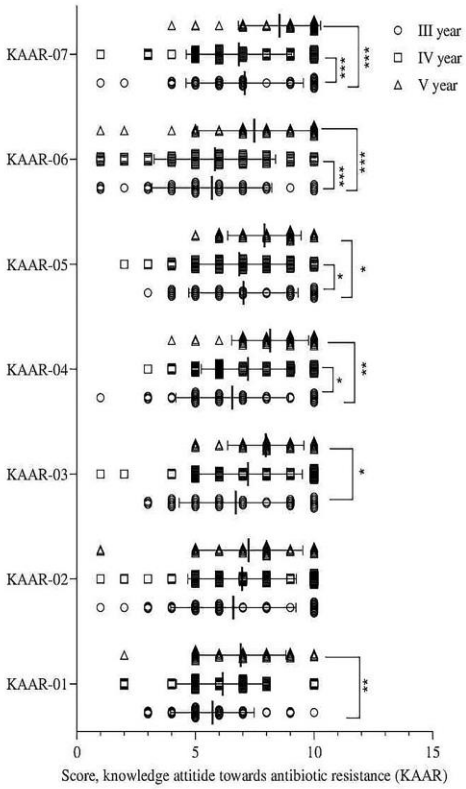

Figure 6: Mean difference of knowledge attitude towards antibiotic resistance (KAAR) among students of different years.

Note: ***p<0.001; **p=0.002-0.09 and *p<0.05. KAAR-01; Few antibiotics being developed, KAAR-02; Prescribing antibiotics when the situation does not warrant its use, KAAR-03; Using the wrong antibiotic for the situation, KAAR-04; Using an inappropriate dose and/or frequency of antibiotic for the situation, KAAR-05; Using antibiotic treatment for a longer duration than what is indicated, KAAR-06; Not prescribing antibiotics when the situation requires its use, KAAR-07; Patient non-compliance with antibiotic treatment (such as not taking it as prescribed, not completing the course, or taking too much).

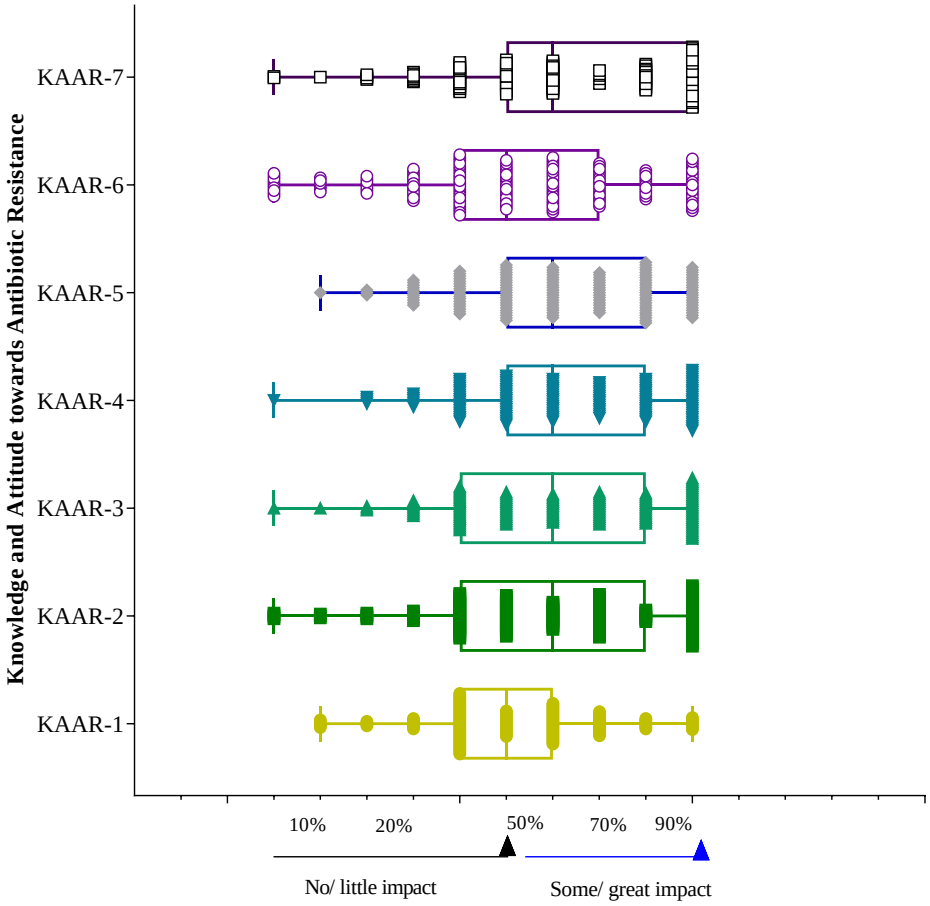

Figure 7: Perceptions of Impact Different Factors Have on Antimicrobial Resistance.
Note KAAR-01; Few antibiotics being developed, KAAR-02; Prescribing antibiotics when the situation does not warrant its use, KAAR-03; Using the wrong antibiotic for the situation, KAAR-04; Using an inappropriate dose and/or frequency of antibiotic for the situation, KAAR-05; Using antibiotic treatment for a longer duration than what is indicated, KAAR-06; Not prescribing antibiotics when the situation requires its use, KAAR-07; Patient non-compliance with antibiotic therapy (such as not taking medication as prescribed, not completing the course, or taking too much).

4.8 Knowledge of Prescribing Guidelines

The students felt that the trust in antimicrobial prescribing guidelines and adherence to these guidelines is essential to reduce the risk of AMR. The Cadet Officer medical students had shown 2.46 times Odds (95% CI 1.12-5.42, p=0.025) compared to civilians (**Figure 8A)** regarding the awareness of the guidelines available in Malaysia to assist with appropriate management of acute coronary syndrome, and the Indian students had lower knowledge compared to Malay

students (OR=0.21, 95% CI 0.06-0.76; p=0.017). No other significant differences were noted for other guidelines (**Figure 8B)**.

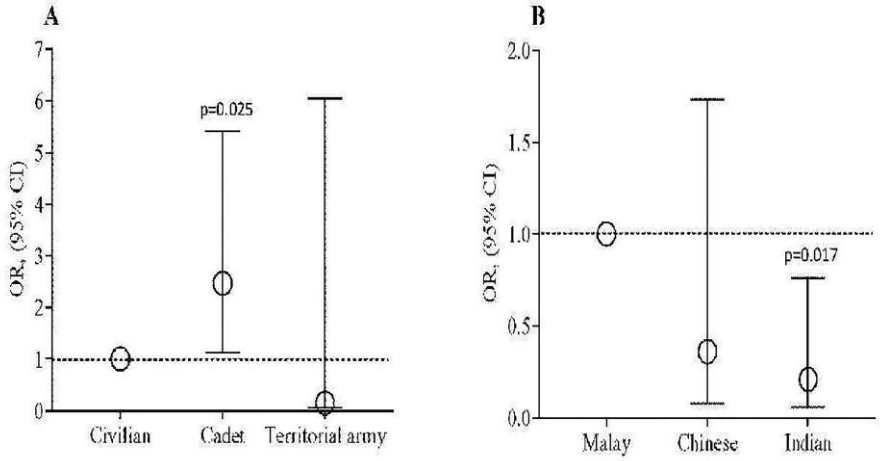

Figure 8: Odds of designation and Ethnicity of the participants about the knowledge of prescribing guidelines.

5. Discussion

The response rate (90.32%) is relatively high. This may be because research respondents were from a military school with strict discipline and a small study population, with good student cooperation.

Encouragingly, most students believed that the Faculty of Medicine and Defence Health provided sufficient teaching-learning educational input regarding commonly prescribed drugs, appropriate and accurate prescription writing principles, and infectious. This is welcomed as an earlier study conducted among medical students in Malaysia requested more educational input regarding antimicrobials prescribing and clinical pharmacology [49]. Our findings are similar to several other studies researching educational input among medical students [50-55]. A previous study in Malaysia showed that most medical students possessed a reasonably good knowledge of antimicrobials [46]. This study also showed that male and female medical students had confidence in appropriate and accurate prescription writing [46].

However, others have reported different findings [44, 49, 51, 56]. In India, Nayak et al. (2021) said that most of the medical students surveyed felt that the current input regarding pharmacology was not sufficient to develop appropriate prescribing skills [44]. Similarly, a study conducted in South Africa reported a low level of prescribing confidence, resulting in more input on clinical pharmacology and prescribing during undergraduate teaching [56]. One study

conducted among both University non-medical and medical students in Malaysia reported that their overall knowledge was low regarding antimicrobials and other health-related issues; however, medical students' knowledge levels were significantly ($p<0.001$) higher regarding antimicrobials and other matters than non-medical participants [57]. Higuita-Gutiérrez et al. (2020) found that a significant proportion of medical students in their study in Colombia found the training on antibiotics and AMR to be mediocre to poor [58]. Similarly, in their systematic review, Nogueira-Uzal et al. (2020) also found a considerable lack of knowledge regarding antibiotics in the combined studies, with 41% - 69% of medical students in the various studies believing antibiotics would help to treat URTIs [59]. This is a concern especially given a high inappropriate prescribing of antibiotics in ambulatory care across countries, including Malaysia LMICs [8, 10, 25].

The finding that Year-V medical students had eight times higher knowledge levels regarding commonly prescribed drugs versus Year-III students is a concern going forward. However, different from studies conducted in South Africa where there were low confidence levels regarding prescribing antibiotics among final year medical students [56] and Spain [51]. The Spanish study found that whilst medical students felt confident in diagnosing infectious diseases, they needed more education and training regarding judiciously prescribed antimicrobials [51]. In Haque et al. (2016) study, medical students in Malaysia also welcomed more education on antibiotic selection, perceiving a gap between theoretical input and clinical practice [49]. This was similar to the situation in India and across Europe, especially among several Central, Eastern, and Southern European countries where there were concerns with knowledge about antibiotics, prescribing skills for common infectious diseases, and AMR, with a need for additional educational input [60-63]. One more study conducted among medical students in France and Sweden found that multimode instructional strategy resulted in better prescribing habits than students exposed to a lower number of teaching-learning methods [61].

Our findings also demonstrate that students' capability to prescribe independently and rationally improves with training, which is encouraging. This contrasts with other studies showing that medical students require more teaching-learning sessions on antimicrobials prescribing for their forthcoming practice [25, 49, 60-68]. We are not sure of the reasons behind this difference. This may reflect differences in teaching approaches, including clinical rotation programs between countries with problem-based learning styles associated with more excellent knowledge about antibiotics and prescribing than traditional learning approaches [63]. Of interest when refining the content of teaching modules for medical students, we found that Year-III and Year-IV students had the same level of confidence in all four components. However, Year-V students exhibited around four to six times higher confidence levels than Year-III.

Furthermore, AMR knowledge and attitude scores were typically lower among Year-III medical students than their seniors. It is evident that as students reach a senior level, their understanding and skills improve, especially with additional input at a senior level [69, 70]. In any event, teaching prudent antibiotic prescribing skills and AMR is essential to reduce rising AMR rates [17, 71].

Encouragingly and both genders in the study found all five modes of teaching were helpful or effective in attaining and improving knowledge about medicine and prescribing. The same situation was seen regarding knowledge of antimicrobials knowledge and prescribing. Additionally, no statistically significant differences were observed regarding the modes of teaching among the genders, year of study, and ethnic origin. The exception was Chinese and Indian medical students in certain aspects. Chinese students felt less benefit in the clinical rotation educational method than other ethnic groups. In addition, Indian medical students appeared to have higher levels of understanding than those from other ethnic origins. As mentioned in their study, van der Voort et al. (2019) found that problem-based learning styles were associated with more excellent knowledge about antibiotics and prescribing than traditional learning approaches [63].

Encouragingly, the medical students showed awareness about the prescribing guidelines available in Malaysia to assist with appropriate disease management and enhance prudent/rational prescribing. Multiple publications have concluded that adherence to guidelines, hospital formularies, and other strategies improve prescribing quality, including antimicrobials [10, 25, 28, 72, 74, 75].

6. Limitation of the Study

This study was cross-sectional with its' inherent limitations. There were also issues with data collection as a result of clinical placements. This impacted the final classification of some students, e.g., some of the Year-V students were wrongly written as Year-IV. The research was only conducted at one University in Malaysia and before the forced closure of universities due to the COVID-19 pandemic. Despite these limitations, we believe the findings will be of interest to other countries and provide guidance to the University in Malaysia.

7. Conclusion

The majority of the clinical medical students of UPNM reported they received sufficient input regarding commonly prescribed medicines, including antimicrobials, appropriate and accurate prescription writing principles, and infectious diseases. Year-V had an 8.0 times higher knowledge level in commonly prescribing medicines than Year-III students and appreciably higher confidence in the principals in prescribing contagious diseases. Year-IV and V students

were also found to have a better understanding of AMR. Generally, as students became more senior, their knowledge, attitude, and understanding regarding infectious disease and AMR improved together with their prescribing skill and confidence, including antimicrobials

8. Recommendation

There is a need for medical students to be familiarized with applying rational approaches to prescribing, including antimicrobials, and should be included earlier in the curriculum. This is even more important due to the pandemic and increased prescribing of antimicrobials for essentially viral infections. In several LMICs countries, especially clinical clerking, teaching, including prescribing skills, has been impaired because of lockdown and movement control order. These challenges need to be addressed earliest possible time.

9. Article Highlights

- This study determines the self-confidence and knowledge of Malaysian medical students of clinical years in managing infectious diseases and prudent antimicrobial prescribing.
- Students reported didactic lectures as the least helpful teaching methods and clinical rotation as the most beneficial.
- The clinical year's medical students surveyed possessed knowledge, sufficiency, and confidence regarding infectious diseases.
- The majority of the medical students knew the guidelines to assist with appropriate antibiotic prescribing.
- This study revealed that medical students reach senior years, knowing and prescribing confidence of antimicrobial medication advances.

Author Contributions

Substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data: MH, TA, MAH, HL, SD, NS, ARA, SSBSM, MMR, SI, NA, RA, SLBA, MHBI, BG; Drafting the article or revising it critically for valuable intellectual content: MH, TA, MAH, HL, SD, NS, ARA, SSBSM, MMR, SI, NA, RA, SLBA, MHBI, BG; Final approval of the version to be published: MH, TA, MAH, HL, SD, NS, ARA, SSBSM, MMR, SI, NA, RA, SLBA, MHBI, BG; Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved: MH, TA, MAH, HL, SD, NS, ARA, SSBSM, MMR, SI, NA, RA, SLBA, MHBI, BG; Project administration: MH, TA, MAH, HL, SD, NS, ARA, SSBSM, MMR, SI, NA, RA, SLBA, MHBI.

Disclosure

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

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