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Future Prescribers and Antibiotic Prescribing: A Nationwide Cross-sectional Survey from Final Year Medical and Dental Students on the Preparedness to Prescribe Antibiotics

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Abstract

Background

Future doctors and dentists will lead antibiotic use in hospitals and communities. Thus, it is crucial to determine if Pakistani medical and dental education prepares students for antibiotic usage. So, we conducted this study to assess medical and dentistry students' preparation, learning methods, and effectiveness of antibiotic usage and resistance teaching and training throughout undergraduate studies in Pakistan.

Methods

A nation-wide multi-center cross-sectional study was conducted in medical and dental colleges from January 2025 to May 2025. Final-year medical and dental students completed a self-administered questionnaire. Descriptive statistics were utilized for categorical data, whereas mean ± SD were used for continuous variables using SPSS version 23.0.

Results

The survey was completed by 1037 medical (RR = 90.1%-1037/1151) and 501 (RR = 94%- 501/533) dentistry students from 16 medical and 8 dental schools. The medical and dental students' least used sources for learning about antibiotic use were active learning assessments, E learning, and peer or near-peer teaching. Medical and dentistry students struggled to prescribe antibiotics according to national recommendations and understand bacterial antibiotic resistance.

Conclusion

No disparities exist between medical and dentistry students' instructional resources and undergraduate themes. To reduce antibiotic abuse and resistance, authorities should implement targeted educational changes to prepare future doctors and dentists to rationalize antibiotic usage.

Introduction

Antibiotic resistance is a prevalent and severe issue within the worldwide healthcare system (HCS), eventually escalating treatment costs, morbidity, and mortality rates [1–4]. Despite the efforts undertaken, the issue of antimicrobial resistance (AMR) is intensifying daily [5]. Several factors contributing to AMR encompass the misuse and excessive application of antimicrobials in agriculture, humans, and animals, the unrestricted over-the-counter accessibility in numerous countries, the lack or ineffective enforcement of antimicrobial stewardship (AMS), the apprehension of adverse outcomes, and insufficient awareness among physicians and medical students concerning the proper utilization of antibiotics [6–15].

Medical and dental students are strategically positioned within the HCS and may significantly contribute to addressing AMR [16]. During their undergraduate studies, medical and dental students must acquire knowledge of the principles of infection detection and therapy, as well as the relationship between antibiotic usage and AMR [17]. Moreover, they must be ready to prescribe antimicrobials judiciously upon beginning their roles as junior doctors

[17–19]. A study evaluating self-reported preparedness regarding responsible antibiotic use among final-year medical students from 28 European countries (Student-PREPARE) indicated that the majority of students believe they require additional education on antibiotic use for their future practice [20]. Parallel research by Dyar OJ et al. indicated that a majority of students (74%) want further instruction on selecting antibiotic treatments, whereas they expressed the most confidence in detecting infections and the lowest confidence in selecting combination medicines [21]. A similar observation was noted among medical students in South Africa [22].

The World Health Organization (WHO) has recognized the education of medical students as a crucial element in the containment of AMR. Surveys conducted in high-income nations repeatedly indicate that medical students acknowledge the significance of antibiotic prescribing knowledge, however perceive themselves as insufficiently prepared and necessitate more instruction on making antibiotic selections [22]. The education of healthcare professionals (HCPs) is an ongoing process; yet, the undergraduate education in medicine, pharmacy, or any allied health subject constitutes the initial step to obtaining pertinent information and establishing a robust foundation for subsequent specialization [23]. Medical and dental students are prospective HCPs who will manage antibiotics in hospitals, primary care, and community environments. Therefore, the future management of difficulties related to bacterial resistance or antibiotic abuse relies on the quality of education, training, and skills acquired at the undergraduate level, underscoring the critical importance of undergraduate studies in the coming years [24]. Nonetheless, some nations implement distinct pedagogical strategies in the early education of HCPs to instruct on appropriate antibiotic utilization [25]. A research by Naeem M et al. indicated that students requested further instruction in antibiotic selection, posology, duration, and the de-escalation and transition from intravenous to oral antibiotic therapy [26]. This study was conducted just in the Punjab region of Pakistan; thus, to formulate comprehensive suggestions and implement reforms statewide, a countrywide study was necessary. Consequently, we assessed the countrywide proficiency of final-year medical students in antibiotic prescription.

Methods

Study Area

Pakistan has four provinces: Punjab, Sindh, Khyber Pakhtunkhwa (KPK), and Balochistan, together with two autonomous administrative regions, Gilgit-Baltistan and Azad Jammu and Kashmir, and the capital territory of Islamabad [27]. The Pakistani education system is organized into six tiers, with MBBS (Bachelor of Medicine and Bachelor of Surgery) classified as a bachelor's degree within the higher education sector [28]. The higher education system for universities is regulated by the Higher Education Commission (HEC), while medical institutions are overseen by both HEC and the Pakistan Medical Council (PMC) [28]. Pakistan has a total of 176 medical colleges, comprising 45 public sector and 72 private sector institutions. Furthermore, there exist 17 public sector and 42 private sector dentistry colleges [29].

Study Design and Study Population

A cross-sectional, paper-based survey was executed across seven government and nine private medical three private and five government dental institutions in three provinces of Pakistan (Punjab, KPK, and Sindh) from January 2025 to May 2025. Final-year students enrolled at these conveniently selected medical colleges were eligible to participate in the poll, contingent upon their willingness. Researchers polled final-year students as they had predominantly finished all topics pertinent to the study's focus. Non-final year students from freshly recognized

medical colleges were not picked due to the absence of final year students in these institutions' inaugural batches. Given the numerous medical and dental colleges in the three provinces of Pakistan, we targeted the most accessible institutions to participate in this study. We extended an invitation to both private and public sector medical and dental schools, accompanied by a concise overview of our aims, methodology, and their potential involvement. The chief investigator (CI) personally visited the institutions between October and December 2024 to enroll the final year students, which was the major aim. During the in-person meeting, we debrief the Dean or Principal of the relevant institution, together with the class teacher or senior instructor of the final academic year. We presented our research group, outlined our research aims, suggested our study design, specified the duration, detailed the procedure, and evaluated their feasibility for participation in and assistance with the study. We informed them that the name, location, or other information pertaining to the medical school would remain confidential and utilized solely for research purposes. We also confirmed that this is only a cross-sectional survey, devoid of any invasive or detrimental procedures, with student participation being voluntary and their identity preserved. We also guaranteed that the institution's anonymity will be preserved. Subsequently, we provided our contact information and requested a response within one week concerning their acceptance or refusal. Subsequent to their agreement, each university designated an associate or assistant professor (AP) to aid in the data gathering procedure for final year students. At the end only 15 private and 9 government institutes (Medical and Dental) were agreed to be the part of this study.

Data Collection Procedure

Eight teams of data collectors, primarily composed of pharmacy or medical students from several regions, were established and compensated monthly during this investigation. At least one AP from each institute was appointed as a master guide to strategize outreach to the target demographic. DCs received training via a Zoom session conducted by CI, which included the following components: (1) Coordination with APs and engagement with persons based on eligibility criteria. (2) Delivering a succinct summary of the study's aims to the participant (Cover letter); (3) Executing the survey or doing in-person interviews; (4) Tackling obstacles faced during data collection. Three teams were designated to gather data from Punjab, three from Sindh, and two from KPK. The training transpired over a two-day period, and following its conclusion, each team was permitted to collect data. The finalized questionnaires were assessed weekly by the APs to monitor progress and participation. Furthermore, to assess compliance with data gathering methods and exclude incomplete forms. If the tool is completely filled then we accept it for the analysis. Individuals with repeated responses or incomplete submissions were excluded from the analysis. Data were gathered via paper-based self-administration throughout a four-month period from January 2025 to May 2025. Upon obtaining authorization from the relevant authorities at the participating colleges, DCs were accompanied to the final year students. The data collection teams initially presented the study's aims and objectives to the students before distributing the survey.

The CI performed targeted investigations and regular assessments to maintain data quality and validity, assuring the thoroughness of the submitted questionnaires. CI also ensured that the same data tool is used throughout the period and most accurate and consistent response were recorded. This was accomplished by prompt data assessment, random verifications, and follow-up interviews. CIs also made sure that the DCs adhere to all the protocol of the training and did not deviate from procedures.

Questionnaire Development and Validity

The survey instrument was created following a comprehensive literature assessment [17, 20, 21, 26, 30, 31]. The survey had 47 items, encompassing inquiries on socio-demographics, self-assessed readiness on 27 curricular themes related to judicious antibiotic use (utilizing a 7-point Likert-type scale), the availability and efficacy of teaching techniques, and the anticipated necessity for additional education in medical school. The tool was accessible in English, which we subsequently enhanced via conversations.

The idea and substance of the questionnaire were validated by a thorough evaluation of the relevant literature. The technique was utilized and validated in a prior study [26], however owing to minor alterations for applicability in our context, we revalidated the questionnaire. The validation method was conducted in a systematic manner; we performed face validity of the instrument through the evaluations of expert researchers who examined the questions included in the instrument. Seven faculty members, primarily APs in pharmacy practice, did the review and assessed the questionnaire. The content validity index (CVI) and content validity ratio (CVR) were computed based on expert opinions. The methodology for assessing the CVI and CVR has been referenced elsewhere [32]. Items having CVI values below 0.78 were revised, and their phrasing was altered accordingly, while items with lower CVR values were omitted from the survey questionnaire. We revised the study tool in accordance with the feedback provided by experts. The survey was tested for efficacy on 30 independent students before being released for data collecting. Through pre-testing, we determined the respondents' willingness to participate in the research and furnish the necessary information. A subset of ten pilot participants was requested to articulate their comprehension of essential concepts and offer input on the phrasing. They were moreover inquired whether they experienced any ambiguity in comprehending any terminology. The wording and scale were elucidated after minor modifications informed by participant feedback. The internal consistency of the questionnaire was assessed using Cronbach's alpha. The Cronbach’s alpha value of 0.681 indicated acceptable internal consistency among the items. The full questionnaire is included in Appendix S1.

Statistical Analysis

Categorical data were reported using frequencies and percentages, while continuous variables were described using mean and standard deviation. Numbers and percentage of participants mentioning each item on 7-point Likert scale was mentioned. We used SPSS version 23.0 for the analysis of data.

Ethical Approval

This cross-sectional study was conducted in compliance with the Declaration of Helsinki and received approval from the Medical Ethics Committees of SIMAD University Mogadishu, Somalia, and the Ethical Review Board of The Superior University, Lahore. A formal pre-approval consent was received from each student. All participants were required to sign the permission form and provide their agreement. No personal information (name, address, phone number, etc.) was solicited intentionally, and participants were told that the data would solely be utilized for research purposes and handled with secrecy. Participation was optional and devoid of any incentives or penalties, allowing students to withdraw from the research at any moment.

Clinical Trail Number: Not Applicable

Results

Demographic details

This study focused on 1151 final-year medical students, of whom 1037 replies were complete and included in the analysis, resulting in a response rate of 90.1%. Among dentistry students, the response rate was 94.0% with 501 out of 533 responses. An almost same proportion of male and female students existed within the two cohorts, and comparable numbers of medical and dentistry students originated from both government and private institutions. The detail has been incorporated into Table 1.

Table 1 Demographic details of medical and dental students

No	Characteristics	Medical students		Dental students		P value
	Age Years	24.2±1.03		23.2±1.2		0.866
1	**Gender**	**N**	**Percentage**	**N**	**Percentage**	
	Male	508	49.0	245	48.9	0.975
	Female	529	51.0	256	51.1	
2	**Nature of institute**					
	Government	568	54.8	275	54.9	0.96
	Private	469	45.2	226	45.1	

This survey evaluated medical students' self-reported readiness in six categories of antibiotic preparedness: infection diagnosis, indications for withholding antibiotics, initial therapy, reassessment, quality of care, and antibiotic resistance. Regarding infection diagnosis, intermediate readiness was indicated for identifying clinical symptoms (28.5%) and analyzing biochemical indicators (e.g., CRP; 28.5% "sufficiently prepared"). Significant deficiencies were identified in point-of-care testing, with 49.3% reporting "moderate preparedness" and 30.6% indicating "no preparedness," as well as in microbiological sample interpretation, where 44.1% felt "moderately prepared" for blood cultures. To prevent the misuse of medications, students faced challenges in distinguishing between bacterial and viral illnesses, with 43.8% feeling "moderately prepared," and in differentiating colonization from infection, with 37.6% feeling "not at all prepared." More than 40% felt ill-equipped to determine whether antibiotics are unwarranted. The selection of empirical antibiotic therapy exhibited significant deficiencies: 40.2% reported feeling "not at all prepared" to select antibiotics in the absence of guidelines, 46.9% expressed a lack of confidence in prescribing according to national guidelines, and decisions regarding allergy assessments and combination therapy demonstrated varied levels of preparedness, with 53.3% indicating "moderate" readiness.

Subsequently, we assessed the readiness for the quality of treatment and communication, revealing that multidisciplinary cooperation and the auditing of antibiotic usage were identified as deficient areas, with 33.4% indicating "not at all prepared." Although 46.8% felt "moderately prepared" to address inappropriate antibiotic use with patients, a significant number lacked confidence in challenging senior physicians, with 33.6% reporting they were "not at all prepared." In assessing knowledge regarding antibiotic resistance, 47% felt ill-equipped to implement resistance mechanisms, 26.7% lacked training on regional resistance patterns, and just 13.4% reported being "sufficiently prepared" in infection control measures. The details have been presented in Table 2.

Table 2: Preparedness of medical students about different parameters regarding antibiotic (N=1037)

Statement	No teaching was provided	Not at all prepared	Moderately	Sufficiently prepared	well prepared	I am unsure how I feel)	I don't understand the question
Preparedness about diagnosis of infection							
To recognize the clinical sign and symptoms	0 (0.0%)	0 (0.0%)	296 (28.5%)	176 (17.0%)	241 (23.2%)	173 (16.7%)	151 (14.6%)
To assess the clinical severity (e.g using the criteria such as the septic shock criteria)	0 (0.0%)	0 (0.0%)	228 (22.0%)	58 (5.6%)	400 (38.6%)	226 (21.8%)	125 (12.1%)
To use point –of-care tests (e.g urine dipstick, rapid diagnostic test for streptococcul pharyngitis)	102 (9.8%)	317 (30.6%)	511 (49.3%)	95 (9.2%)	12 (1.2%)	0 (0.0%)	0 (0.0%)
To interpret biochemical markers of inflammation (e.g CRP)	49 (4.7%)	50 (4.8%)	100 (9.6%)	296 (28.5%)	295 (28.4%)	198 (19.1%)	49 (4.7%)
To decide when it is important to take microbiological samples before starting antibiotic therapy	0 (0.0%)	129 (12.4%)	518 (50.0%)	325 (31.3%)	65 (6.3%)	0 (0.0%)	0 (0.0%)
To interpret basic microbiological investigations (e.g blood cultures)	0 (0.0%)	194 (18.7%)	457 (44.1%)	257 (24.8%)	129 (12.4%)	0 (0.0%)	0 (0.0%)
Preparedness about indications for no antibiotic treatment							
To identify clinical situation when not to prescribe an antibiotic	193 (18.6%)	0 (0.0%)	455 (43.9%)	132 (12.7%)	65 (6.3%)	64 (6.2%)	128 (12.3%)
To differentiate between bacterial colonization and infection (e.g symptomatic beteriuria)	67 (6.5%)	390 (37.6%)	322 (31.1%)	194 (18.7%)	64 (6.2%)	0 (0.0%)	0 (0.0%)
To differentiate between bacterial and viral upper	0 (0.0%)	261 (25.2%)	454 (43.8%)	258 (24.9 %)	0 (0.0%)	64 (6.2%)	0 (0.0%)

respiratory tract infection.							
Preparedness about initial antibiotic therapy							
To select initial empirical therapy based on the most likely pathogen(s) and antibiotic resistant pattern without using guidelines	0 (0.0%)	417 (40.2%)	482 (46.5%)	138 (13.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
To decide the urgency of antibiotic administration in different situations (e.g<1 hour for severe sepsis, non-urgent for chronic bone infection)	0 (0.0%)	137 (13.2%)	485 (46.8%)	346 (33.4%)	69 (6.7%)	0 (0.0%)	0 (0.0%)
To prescribe antibiotic therapy according to national guidelines	0 (0.0 %)	486 (46.9%)	482 (46.5%)	69 (6.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
To asses antibiotic allergies (e.g differentiating between anaphylaxis and hypersensitivity)	68 (6.6%)	68 (6.6%)	553 (53.3%)	209 (20.2%)	139 (13.4%)	0(0.0%)	0 (0.0%)
To decide indications for combination therapy	0 (0.0%)	139 (13.4%)	621 (59.9%)	277 (26.7%)	0 (0.0%)	0 (0.0%)	0 0.0(%)
To decide the shortest possible adequate duration of antibiotic therapy for a specific infection	0 (0.0%)	139 (13.4%)	551 (53.1%)	278 (26.8%)	69 (6.7%)	0 (0.0%)	0 (0.0%)
To prescribe using principles of surgical antibiotic prophylaxis	68 (6.6%)	68 (6.6%)	553 (53.3%)	209 (20.2%)	139 (13.4%)	0 (0.0%)	0 (0.0%)
Preparedness about reassessment of antibiotic therapy							
To review the need to continue or change antibiotic therapy after 48-72 hours	0 (0.0%)	277 (26.7%)	623 (60.1%)	69 (6.7%)	0 (0.0%)	68 (6.6%)	0 (0.0%)

based on clinical evolution and laboratory results							
To assess clinical outcomes and possible reasons for failure of antibiotic treatment	0 (0.0%)	140 (13.5%)	276 (26.6%)	70 (6.8%)	139 (13.4%)	206 (19.9%)	0 (0.0%)
To decide when to switch from intravenous (IV) to oral antibiotic therapy	0 (0.0%)	68 (6.6%)	413 (39.8%)	348 (33.6%)	208 (20.1%)	0 (0.0%)	0 (0.0%)
Preparedness about quality of care							
To measure/audit antibiotic use in a clinical setting, and to interpret the results of such studies	0 (0.0%)	346 (33.4%)	416 (40.1%)	69 (6.7%)	69 (6.7%)	69 (6.7%)	68 (6.6%)
To work within the multi-disciplinary team in managing antibiotic use in hospital.	206 (19.9%)	204 (19.7%)	140 (13.5%)	280 (27.0%)	69 (6.7%)	69 (6.7%)	69 (6.7%)
To discuss antibiotic use with patient who are asking for antibiotic, when I feel they are not necessary	0 (0.0%)	137 (13.2%)	485 (46.8%)	278 (26.8%)	137 (13.2%)	0 (0.0%)	0 (0.0%)
To communicate with senior doctors in situation where I feel antibiotics are not necessary, but I feel I am being inappropriately pressured into prescribing antibiotic by senior doctors	69 (6.7%)	348 (33.6%)	279 (26.9%)	0 (0.0%)	69 (6.7%)	204 (19.7%)	68 (6.6%)
Preparedness about antibiotic resistances							
To use knowledge of the common mechanism of antibiotic resistance in pathogen	0 (0.0%)	487 (47.0%)	208 (20.1%)	139 (13.4%)	0 (0.0%)	68 (6.6%)	135 (13.0%)

To use knowledge of epidemiology of bacterial resistance, including local/regional variations	277 (26.7%)	278 (26.8%)	139 (13.4%)	0 (0.0%)	0 (0.0%)	138 (13.3%)	205 (19.8%)
To practice effective infection control and hygiene (to prevent spread of bacteria)	140 (13.5%)	210 (20.3%)	139 (13.4%)	69 (6.7%)	0 (0.0%)	274 26.4(%)	205 (19.8%)
To use knowledge of the negative consequences of antibiotic use (bacterial resistance, toxic/adverse effects, cost, clostridium difficale infection)	67 (6.5%)	138 (13.3 %)	278 (26.8%)	209 (20.2%)	138 (13.3%)	138 (13.3%)	69 (6.7%)

Table 3 delineates the frequency with which various pedagogical approaches are regarded in the education of medical students about antibiotic usage and resistance. We noted that the predominant technique employed was lectures (with over 15 participants) with 40.1% of respondents rating it as "neutral" in terms of usefulness, while 13.4% deemed it "useful." Nonetheless, 13.5% indicated that this strategy was "not utilized." Conversely, least utilized or least efficacious methods was active learning assignments (e.g., article reading, group work) - 86.7% indicated that this strategy was "not utilized," while just 6.7% deemed it "not at all useful" or "neutral."

Table 3: Teaching methods used for antibiotic education among medical students (N=1037).

How did you feel about the following source used to teach you about the antimicrobial use and resistance

Method	Method not used	Not at all useful	Neutral	Useful	Very useful	I am unsure	I do not understand the question
Lectures (with >15people)	140 (13.5%)	139 (13.4%)	416 (40.1%)	139 (13.4%)	0 (0.0%)	68 (6.6%)	135 (13.0%)
Small group teaching (<15 students)	280 (27.0%)	70 (6.8%)	70 (6.8%)	207 (20.0%)	69 (6.7%)	137 (13.2%)	204 (19.7%)
Discussions of clinical cases	278 (26.8%)	70 (6.8%)	210 (20.3%)	69 (6.7%)	137 (13.2%)	204 (19.7%)	69 (6.7%)
Active learning assignments (e.g article reading, group work)	899 (86.7%)	69 (6.7%)	69 (6.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
E-learning	762 (73.5%)	0 (0.0%)	275 (26.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Role play or communication skills session dealing with patient demanding antibiotic therapy	69 (6.7%)	70 (6.8%)	210 (20.3%)	209 (20.2%)	138 (13.3%)	204 (19.7%)	137 (13.2%)
Infectious disease clinical placement (i.e clinical rotation or training in infectious disease, involving patients	0 (0.0%)	0 (0.0%)	208 (20.1%)	414 (39.9%)	139 (13.4%)	207 (20.0%)	69 (6.7%)
Microbiology clinical placements	555 (53.5%)	0 (0.0%)	482 (46.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Peer or near-peer teaching (teaching lead by other students, or recently qualified doctors)	560 (54.0%)	17 (1.6%)	455 (43.9%)	2 (0.2%)	3 (0.3%)	0 (0.0%)	4. (0.0%)

Table 4 evaluated dentistry students' self-reported readiness for antibiotic prescription and management across the six areas previously outlined for medical students. Each parameter is evaluated on a continuum ranging from "no teaching was provided" to "well prepared." The majority of respondents felt somewhat (29.5%) or sufficiently (19.8%) prepared for diagnosing the sign and symptoms of infections. Additionally, 38.1% felt well prepared for assessing clinical severity (e.g., septic shock criteria), although 20.8% were uncertain, highlighting deficiencies in critical evaluation. In the context of indications for refraining from antibiotic treatment, 43.5% reported feeling fairly equipped to identify when not to prescribe, while 43.8% felt moderately prepared to distinguish between bacterial and viral illnesses. We also evaluated the reevaluation of antimicrobial therapy. 26.7% felt entirely unprepared, indicating a missed chance for stewardship, whereas 33.3% felt well prepared for transitioning from intravenous to oral medication.

Table 4: Preparedness dental students about different parameters regarding antibiotic usage (N=501)

Statement	No teaching was provided	not at all prepared	Moderately	Sufficiently prepared	well prepared	I am unsure how I feel	I don't understand the question
Preparedness about diagnosis of infection							
To recognize the clinical sign and symptoms	0 (0.0%)	0 (0.0%)	148 (29.5%)	99 (19.8%)	105 (21.0%)	81 (16.2%)	68 (13.6%)
To assess the clinical severity (e.g using the criteria such as the septic shock criteria)	0 (0.0%)	0 (0.0%)	117 (23.4%)	32 (6.4%)	191 (38.1%)	104 (20.8%)	57 (11.4%)
To use point – of- care tests (e.g urine dipstick, rapid diagnostic test for streptococcul pharyngitis)	42 (8.4%)	133 (26.5%)	270 (53.9%)	49 (9.8%)	7 (1.4%)	0 (0.0%)	0 (0.0%)
To interpret biochemical markers of inflammation (e.g CRP)	24 (4.8%)	23 (4.6%)	47 (9.4%)	142 (28.3%)	145 (28.9%)	96 (19.2%)	24 (4.8%)
To decide when it is important to take microbiological samples before starting antibiotic therapy	0 (0.0%)	63 (12.6%)	252 (50.3%)	156 (31.1%)	30 (6.0%)	0 (0.0%)	0 (0.0%)
To interpret basic microbiological investigations (e.g blood cultures)	0 (0.0%)	93 (18.6%)	222 (44.3%)	125 (25.0%)	61 (12.2%)	0 (0.0%)	0 (0.0%)
Preparedness about indications for no antibiotic treatment							
To identify clinical situation when not to prescribe an antibiotic	0 (0.0%)	93 (18.6%)	218 (43.5%)	64 (12.8%)	31 (6.2%)	32 (6.4%)	63 (12.6%)
To differentiate between bacterial colonization and infection (e.g symptomatic beteriuria)	32 (16.1%)	189 (37.7%)	156 (31.1%)	92 (18.4%)	32 (6.4%)	0 (%)	0 (%)

To differentiate between bacterial and viral upper respiratory tract infection.	0 (0.0%)	125 (25.0%)	220 (43.8%)	125 (25.0%)	31 (6.2%)	0 (%)	0 (%)
Preparedness about initial antibiotic therapy							
To select initial empirical therapy based on the most likely pathogen(s) and antibiotic resistant pattern without using guidelines	0 (0.0%)	199 (39.7%)	235 (46.9%)	67 (13.4%)	0 (%)	0 (%)	0 (%)
To decide the urgency of antibiotic administration in different situations (e.g<1 hour for severe sepsis, non-urgent for chronic bone infection)	0 (0.0%)	68 (13.6%)	234 (46.7%)	165 (32.9%)	34 (6.8%)	0 (0.0%)	0 (0.0%)
To prescribe antibiotic therapy according to national guidelines	0 (0.0%)	233 (46.5%)	235 (46.9%)	33 (6.6%)	0 (%)	0 (%)	0 (%)
To asses antibiotic allergies (e.g differentiating between anaphylaxis and hypersensitivity)	34 (6.8%)	34 (6.8%)	226 (53.1%)	100 (20.0%)	67 (13.4%)	0 (%)	0 (%)
To decide indications for combination therapy	0 (%)	67 (13.4%)	301 (60.1%)	133 (26.5%)	0 (%)	0 (%)	0 (%)
To decide the shortest possible adequate duration of antibiotic therapy for a specific infection	0 (%)	67 (13.4%)	268 (53.5%)	133 (26.5%)	33 (6.6%)	0 (%)	0 (%)
To prescribe using principles of surgical	34 (6.8%)	34 (6.8%)	266 (53.1%)	100 (20.0%)	67 (13.4%)	0 (0.0%)	0 (0.0%)

antibiotic prophylaxis							
Preparedness about reassessment of antibiotic therapy							
To review the need to continue or change antibiotic therapy after 48-72 hours based on clinical evolution and laboratory results	0 (0.0%)	134 (26.7%)	300 (59.9%)	33 (6.6%)	33 (6.6%)	0 (0.0%)	0 (0.0%)
To assess clinical outcomes and possible reasons for failure of antibiotic treatment	0 (0.0%)	66 (13.2%)	132 (26.3%)	33 (6.6%)	67 (13.4%)	102 (20.4%)	101 (20.2%)
To decide when to switch from intravenous (IV) to oral antibiotic therapy	0 (0.0%)	34 (6.8%)	199 (39.7%)	167 (33.3%)	101(20.2%)	0 (0.0%)	0 (0.0%)
Preparedness about quality of care							
To measure/audit antibiotic use in a clinical setting, and to interpret the results of such studies	0 (0.0%)	166 (33.1%)	201(40.1%)	34 (6.8%)	33 (6.6%)	33 (6.6%)	34(6.8%)
To work within the multi-disciplinary team in managing antibiotic use in hospital.	101 (20.2%)	100 (20.0%)	66 (13.2%)	132 (26.3%)	34 (6.8%)	34 (6.8%)	34 (6.8%)
To discuss antibiotic use with patient who are asking for antibiotic, when I feel they are not necessary	0 (0.0%)	68 (13.6%)	234 (46.7%)	133 (26.5 %)	66 (13.2%)	0 (0.0%)	0 (0.0%)
To communicate with senior doctors in situation where	34 (6.8%)	167 (33.3%)	133 (26.5%)	33 (6.6%)	100 (20.0%)	34 (6.8%)	0 (0.0%)

I feel antibiotics are not necessary, but I feel I am being inappropriately pressured into prescribing antibiotic by senior doctors							
Preparedness about antibiotic resistance							
To use knowledge of the common mechanism of antibiotic resistance in pathogen	0 (0.0%)	233 (46.5%)	100 (20.0%)	67 (13.4%)	34 (6.8%)	67 (13.4%)	0 (0.0%)
To use knowledge of epidemiology of bacterial resistance, including local/regional variations	134 (26.7%)	134 (26.7%)	66 (13.2%)	0(0.0%)	0 (0.0%)	67 (13.4%)	100(20.0%)
To practice effective infection control and hygiene (to prevent spread of bacteria)	66 (13.2%)	99 (19.8%)	67 (13.4%)	34 (6.8%)	0 (0.0%)	135 (26.9%)	100(20.0%)
To use knowledge of the negative consequences of antibiotic use (bacterial resistance, toxic/adverse effects, cost, clostridium difficale infection)	33 (6.6%)	67 (13.4%)	133 (26.5%)	99 (19.8%)	67 (13.4%)	68 (13.6%)	5. (6.8%)

Table 5 assesses the prevalence and perceived efficacy of several instructional techniques in training dentistry students with antimicrobial usage and resistance. The predominant approach employed was lectures (>15 participants), 40.1% deemed lectures "neutral" in utility, while 13.4% saw them as "useful". The second most prevalent approach was infectious disease Clinical Placements, with 39.9% deeming them "Useful" and 13.2% categorizing them as "Very useful." Among the least utilized ways, Active Learning Assignments (e.g., article reading, group work) ranked highest, with 86.4% indicating the approach was "not used," while just 6.8% deemed it "not at all useful." Subsequently, in E-learning, 73.1% indicated it was "not utilized," and 26.9% remained indifferent.

Table 5: Teaching methods used for antibiotic education among dental students (N=501).

How did you feel about the following source used to teach you about the antimicrobial use and resistance?							
Method	**Method not used**	**Not at all useful**	**Neutral**	**Useful**	**Very useful**	**I am unsure**	**I do not understand the question**
Lectures (with >15people)	66 (13.2%)	66 (13.2%)	201 (40.1%)	67 (13.4%)	0 (0.0%)	34 (6.8%)	67 (13.4%)
Small group teaching (<15 students)	132 (26.3%)	33 (6.6%)	33 (6.6%)	102 (20.4%)	34 (6.8%)	67 (13.4%)	100 (20.0%)
Discussions of clinical cases	134 (26.7%)	33 (6.6%)	99 (19.8%)	34 (6.8%)	68 (13.6%)	100 (20.0%)	33 (6.6%)
Active learning assignments (e.g article reading, group work)	433 (86.4%)	34 (6.8%)	34 (6.8%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
E-learning	366 (73.1%)	(%)	135 (26.9%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Role play or communication skills session dealing with patient demanding antibiotic therapy	33 (6.6%)	33 (6.6%)	99(19.8%)	100 (20.0%)	67 (13.4%)	101 (20.2%)	68 (13.6%)
Infectious disease clinical placement (i.e clinical rotation or training in infectious disease, involving patients	0 (0.0%)	0(0.0%)	100 (20.0%)	200 (39.9%)	66 (13.2%)	101 (20.2%)	34 (6.8%)
Microbiology clinical placements	0 (0.0%)	265 (52.9%)	236 (47.1)	0 (0.0%)	0 (0.0%)	0(0.0%)	0 (0.0%)
Peer or near-peer teaching (teaching lead by other students, or recently qualified doctors)	268 (53.5%)	11 (2.2%)	219 (43.7%)	3 (0.6%)	0 (0.0%)	0(0.0%)	0 (0.0%)

Discussion

Students requested education on the judicious use of antibiotics, and it is the responsibility of mentors to impart suitable knowledge regarding antibiotic usage to mitigate illogical practices [26, 32]. While prior research has assessed the preparedness to administer or utilize antibiotics among pharmacy and medical students in Punjab, Pakistan, a thorough nationwide study involving medical and dentistry students is essential to provide a full understanding of the national issue. This is the inaugural research of its kind that evaluated medical and dentistry students' self-reported preparation, the efficacy of various learning techniques, the breadth of subjects addressed, and the preferred teaching materials regarding antibiotic usage and resistance throughout three provinces of Pakistan. This study revealed that final-year medical and dentistry students were inadequately trained to identify and prescribe antibiotics. Our research aligns with other studies conducted in Pakistan [26], France [17], and other European regions [20,21]. Likewise, a significant proportion of pharmacy students in Qatar asserted that pharmacists

have to complete prescribing training and get certification prior to being legally permitted to prescribe medications [33].

Some important aspects of prudent antibiotic use were perceived poorly by our cohort i.e 1 in 5 participants from both the cohort said they are not prepared at all for To interpret basic microbiological investigations (e.g blood cultures), and two in five medical/dental students feel unprepared on the complexities in selection of the best antimicrobial for a specific infection in daily practice, prescribe antibiotic therapy according to national guidelines and use knowledge of the common mechanism of antibiotic resistance in pathogen. These gaps were also observed in the previous studies from Pakistan among the pharmacy and medical students [26]. These gaps in training during undergraduate studies may also be correlated with the shortcomings identified in antibiotics prescriptions in hospitals in Pakistan where duration of antibiotic therapy or doses of antibiotics and switch from intravenous to oral or route of administration were absent or wrongly mentioned on the prescriptions [34,35]. Furthermore, students may view the infection management as a complex phenomenon and less understanding of guidelines because of their low consistency and difficult nature of understanding [36,37].

Our findings indicated that traditional learning methods, such as classical classroom lectures, were not seen as effective or favored among medical and dentistry students in Pakistan. A significant majority of the cohort saw problem-based learning, including role play and patient communication during infectious disease clinical placements, as an effective strategy that enhances students' comprehension. Numerous research endorsed the notion that active and interactive learning modalities exert a greater and more enduring impact on prescribing behaviors in later professional life [26, 38, 39]. Moreover, regarding adult learning behavior, it is advantageous to instruct concepts using a disease-oriented approach (e.g., urinary tract infections) or a problem-oriented approach (e.g., antimicrobial resistance) instead of a drug-oriented approach (e.g., memorizing antibiotic classifications) or a pathogen-oriented approach (e.g., methicillin-resistant Staphylococcus aureus) [40, 41].

Implication of our study

Based on the findings, the current study suggests the following implications for policy, practice, and further research. Success of Antibiotic Stewardship Program (ASP) is highly dependent on the HCPs knowledge and integration between the different HCPs [42,43]. So, imparting appropriate knowledge about judicious use of antibiotics would be ultimate success for the ASP. For this, we suggest integrating dedicated modules on antibiotic stewardship in the subject of Pharmacology or Clinical Pharmacy. Second, clinical rotation in infectious diseases should be a priority in future curricula reforms especially in the pharmacy. Third, the addition of inter-professional workshops right at the start of undergraduate training to overcome future barriers in working as a team. Fourthly, there should be a change in educational resources and students should practice the use of standard guidelines. Finally, there is a crucial need for further research to understand how students' self-perceived preparedness reflects observed preparedness and how this in turn translates into clinical practice.

Strength and limitation of the study

This is the inaugural comprehensive statewide comparison research documenting current practices and perceived preparation of medical and dentistry students regarding antibiotic usage. Moreover, as students from both private and public medical and dental colleges throughout three provincial regions of Pakistan participated, the results are likely to be significantly pertinent to all institutions nationwide. The study discovered particular deficiencies in instruction and highlighted inadequately prepared aspects about judicious antibiotic utilization. We observed the subsequent limitations of the study. Our study did not recruit students or colleges by random sampling, but rather

through convenience; nonetheless, we do not believe this will have introduced considerable selection bias due to the study's topic and the absence of incentives for participation. Institutions affiliated with the Pakistan Armed Forces were excluded from the sample due to the protracted process of obtaining authorization from General Headquarters. Given the sample's variety, as students from a significant number of universities participated, the results seem generalizable and presumably reflect the national context. A further problem of this study was evaluative bias. The survey questions may not have comprehensively addressed all aspects of readiness, educational resources, or teaching techniques related to antibiotic resistance, antibiotic treatment, and antibiotic stewardship. Given that several questions necessitated respondents to retrieve specific material, there was a potential danger of recollection bias.

Conclusion

Medical and dental students exhibited inadequate self-assessed preparation and require more training in antibiotic selection, dosage, duration, and the de-escalation and transition from intravenous to oral antibiotic treatment. Neither medical nor dental students deemed lecture-based learning effective for understanding the usage of antibiotics. There exists a compelling rationale for action, and we implore educational policymakers in Pakistan to advance the outdated curriculum of the BDS and MBBS degree programs to incorporate problem-based learning and enhanced practical experience. This type of instruction should start at an early level, within the undergraduate curriculum, to guarantee optimal impact and to cultivate appropriate attitudes.

Declarations

Ethics approval and consent to publish

We received approval from the Medical Ethics Committees of SIMAD University Mogadishu, Somalia, and the Ethical Review Board of The Superior University, Lahore. A formal pre-approval consent was received from each student. All participants were required to sign the permission form and provide their agreement.

Consent for publication.

Not applicable

Availability of data material

Data is available from the corresponding author upon proper request

Competing interest:

Author discloses no competing interest to declare

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Author contribution:

AHG, HMN, designed the study. AHG, HA, helped collecting the data**.** AHG, HAA analyzed the data. AHG wrote the initial manuscripts and, HMN revised the manuscript. HMN and HAA monitored the whole study.

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