Journal of Pioneering Medical Sciences
Received: March 16, 2026 | Accepted: September 30, 2026 | Published: November 05, 2026
Volume 15, Issue 10, Pages 127-136

DOI https://doi.org/10.47310/jpms2026151013



Effect of a Guideline-Based Educational Intervention on Antibiotic-Prescribing Knowledge Among Dental Students at Al-Baha University

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Abstract **Background:** Inappropriate antibiotic prescribing in dentistry contributes to antimicrobial resistance and remains a concern in endodontic practice. Although evidence-based guidelines recommend restricting systemic antibiotics to specific clinical indications, gaps in antibiotic-prescribing knowledge persist among dental students. Evidence regarding the effectiveness of guideline-based educational interventions among dental students in Saudi Arabia remains limited. **Objective:** To assess baseline knowledge of evidence-based antibiotic prescribing for endodontic conditions among clinical-level dental students at Al-Baha University and evaluate changes in questionnaire-based knowledge following a structured, guideline-based educational intervention. **Methods:** A single-center, pre-post educational intervention study was conducted among male clinical-level dental students at Al-Baha University. Electronic questionnaires assessing knowledge of antibiotic indications, antibiotic selection, treatment duration and antimicrobial resistance were administered before and after a structured educational workshop based on European Society of Endodontology guidelines. Baseline responses were obtained from 81 students and post-intervention responses from 69 students. Individual-level matching between the two assessments has not been established. **Results:** The proportion of correct responses was higher in the post-intervention assessment across the evaluated knowledge domains. Correct responses regarding antibiotic use in irreversible pulpitis increased from 30.8% (25/81) before the workshop to 82.6% (57/69) afterward, while correct responses for localized apical abscess without systemic involvement increased from 28.4% (23/81) to 79.7% (55/69). Recognition of amoxicillin as a first-line antibiotic increased from 51.9% (42/81) to 88.4% (61/69). Awareness of antimicrobial resistance increased from 44.4% (36/81) to 91.3% (63/69). These findings represent descriptive differences between the two assessments. **Conclusion:** Higher proportions of correct questionnaire responses were observed following the guideline-based educational intervention, suggesting a potential benefit of structured antimicrobial stewardship education in undergraduate dental training. However, the absence of a control group and uncertainty regarding participant-level matching limit causal interpretation. Further studies incorporating validated assessments, matched longitudinal observations and clinical prescribing outcomes are warranted.

Key Words Antibiotic Stewardship, Endodontics, Dental Education, Prescribing Practice, Antimicrobial Resistance

INTRODUCTION

Antimicrobial resistance (AMR) represents a major global public health challenge, compromising the effectiveness of antimicrobial treatment and increasing the burden of infectious diseases. Inappropriate antibiotic use contributes to the emergence and spread of resistant microorganisms, resulting in increased treatment complexity, healthcare expenditure and adverse clinical outcomes [1]. Dental antibiotic prescribing contributes to overall antimicrobial consumption and previous investigations have identified prescriptions that are inconsistent with established clinical recommendations [2,3]. These concerns highlight the importance of strengthening evidence-based antibiotic decision-making during undergraduate dental education.

Endodontic infections constitute one of the most common reasons for dental pain and emergency dental visits. However, contemporary evidence confirms that most pulpal and periapical infections require operative intervention rather than systemic antibiotic therapy [4,5]. International guidelines from the European Society of Endodontology (ESE) and the

American Dental Association specify that antibiotics should be reserved only for cases exhibiting systemic involvement, spreading infection or compromised host immunity [4,5]. Despite these recommendations, inappropriate antibiotic prescribing for irreversible pulpitis and localized apical abscess remains widely reported across dental practices worldwide [6,7].

Studies mapping global antibiotic use in dentistry reveal substantial geographic variation and widespread deviation from evidence-based protocols [6,8]. Surveys among dental practitioners and students consistently demonstrate insufficient understanding of antibiotic indications, dosing and treatment duration [9-12]. Such knowledge gaps are primarily attributed to inadequate undergraduate teaching of antibiotic stewardship and limited exposure to guideline-driven clinical decision-making [13].

Dental students represent the next generation of prescribers; hence their educational preparation directly influences future prescribing behaviors. Educational interventions have shown success in improving antibiotic-related knowledge and rational prescribing decisions among dental trainees [14,15]. Guideline-based workshops, clinical case discussions and stewardship modules have been recommended as essential curricular components to counter the escalating threat of AMR [16].

Within Saudi Arabia, antimicrobial stewardship initiatives have emphasized the importance of rational antibiotic use across healthcare disciplines. Previous studies have examined antibiotic-prescribing knowledge, attitudes and reported practices among dental students and dental professionals [9,12]. However, evidence specifically evaluating changes in guideline-based antibiotic-prescribing knowledge following structured educational interventions among Saudi dental students remains limited. Assessing baseline knowledge and comparing questionnaire responses before and after educational training may help identify areas requiring greater emphasis in undergraduate dental curricula.

Accordingly, the present study aimed to assess knowledge of evidence-based antibiotic prescribing among clinical-level dental students at Al-Baha University and compare questionnaire responses obtained before and after a structured educational workshop based on European Society of Endodontology recommendations. The assessment focused on recognition of appropriate antibiotic indications, antibiotic selection, treatment duration and awareness of antimicrobial resistance. Responses to clinical scenarios were considered indicators of questionnaire-based knowledge and intended prescribing decisions rather than evidence of actual clinical prescribing behavior. The findings were intended to identify educational knowledge gaps and inform the development of antimicrobial stewardship teaching within the undergraduate dental curriculum.

MATERIALS AND METHODS

Study Design and Setting

A single-center, uncontrolled pre-post educational intervention study was conducted at the Faculty of Dentistry, Al-Baha University, Saudi Arabia. The study assessed questionnaire-based knowledge of evidence-based antibiotic prescribing among clinical-level dental students before and after a structured educational workshop entitled "How and When to Prescribe Antibiotics in Endodontic Treatments." No separate control group was included. Consequently, differences observed between the pre-intervention and post-intervention assessments were interpreted as changes associated with the educational intervention rather than definitive evidence of a causal effect. Potential influences of repeated questionnaire exposure, testing effects and other temporal factors were considered when interpreting the findings.

Sampling Method

The study was conducted at a single dental institution and involved clinical-level male dental students and interns. The eligible population was defined according to academic level and clinical training status. Questionnaire participation was voluntary and responses were obtained from students who completed the respective assessments. The study therefore represents a single-center, non-probability sample. The findings should be interpreted within the context of the participating students and should not be considered representative of dental students across Saudi Arabia.

Study Population

The study was conducted among male dental students enrolled in the clinical stages of undergraduate dental education and dental interns at Al-Baha University, Saudi Arabia. Students in the first, second and third academic years were excluded because they had not yet commenced clinical training. Eligible participants included students from the fourth, fifth and sixth academic years and the internship program. Recruitment was restricted to male students due to institutional arrangements governing student participation and access during the study. Female students were therefore not included in the study population. This restriction was acknowledged as a limitation affecting the generalizability of the findings, particularly their applicability to female dental students and the broader dental student population.

Sample Size and Response Rates

The study used a single-center, non-probability sampling approach involving eligible clinical-level dental students and interns. The sample was determined by the number of eligible students available within the institution rather than through probability-based recruitment. A formal a priori sample-size or statistical power calculation was not documented. Consequently, the adequacy of the achieved sample size to detect a prespecified intervention effect could not be established. The findings were therefore interpreted as exploratory.

Baseline questionnaire responses were obtained from 81 students, comprising 23 fourth-year students, 28 fifth-year students, 19 sixth-year students and 11 interns. The post-intervention questionnaire was completed by 69 students, comprising 19 fourth-year students, 24 fifth-year students, 16 sixth-year students and 10 interns.

Questionnaire Development

A structured electronic questionnaire was developed to assess dental students' knowledge of evidence-based antibiotic prescribing in endodontic practice. The questionnaire covered four principal domains: recognition of clinical indications for systemic antibiotic therapy, selection of appropriate antibiotic agents, knowledge of recommended treatment duration and awareness of antimicrobial resistance and the consequences of inappropriate antibiotic use.

The questionnaire was administered electronically using Google Forms during the pre-intervention and post-intervention assessments. Responses were evaluated according to the answer classifications used for the study and the proportions of responses classified as correct were summarized for each assessed item. The questionnaire-based assessment was intended to evaluate knowledge and responses to prescribing-related questions rather than actual antibiotic prescriptions issued in clinical practice.

Questionnaire Validity and Reliability

The questionnaire was designed to evaluate knowledge of antibiotic indications, antibiotic selection, treatment duration and antimicrobial resistance in endodontic practice. The manuscript documentation did not establish whether the instrument had undergone formal content validation, expert review, pilot testing or reliability assessment before administration. No questionnaire-specific validity coefficients or reliability statistics were available for reporting. Consequently, the psychometric properties of the instrument could not be established from the available documentation. This limitation was considered when interpreting the questionnaire-based findings.

Assessment of Questionnaire Responses

Questionnaire responses were evaluated across four domains: antibiotic indications in endodontic conditions, antibiotic selection, treatment duration and antimicrobial resistance awareness. The results were summarized as the number and percentage of responses classified as correct for each assessed item. The original manuscript did not specify whether individual questions permitted single or multiple correct answers, whether partial-credit scoring was applied or whether a composite knowledge score was calculated. Accordingly, the reported findings were interpreted as item-level correct-response proportions rather than validated overall knowledge scores.

Educational Intervention

A structured educational workshop entitled “How and When to Prescribe Antibiotics in Endodontic Treatments” was conducted to improve dental students' knowledge of evidence-based antibiotic prescribing. The educational content was based on the European Society of Endodontology position statement on antibiotic use in endodontics [4] and was supplemented by the American Association of Endodontists guidance on systemic antibiotic use [17].

The workshop addressed clinical indications for systemic antibiotic therapy in endodontic infections, appropriate antibiotic selection, principles of rational antibiotic prescribing and the consequences of unnecessary antibiotic use. Case-based clinical discussions were incorporated to reinforce the distinction between endodontic conditions requiring definitive dental treatment alone and those in which systemic antibiotics may be indicated. The educational content also addressed antimicrobial resistance and the importance of antibiotic stewardship in dental practice.

The workshop was followed by a post-intervention electronic questionnaire assessing the same broad knowledge domains evaluated at baseline.

Intervention Fidelity and Workshop Participation

The educational intervention was delivered as a structured workshop focusing on evidence-based antibiotic prescribing in endodontic practice. The available study documentation did not establish the total number of students who attended the workshop, whether attendance was mandatory or whether all participants received identical educational exposure. Furthermore, workshop attendance could not be linked to individual pre-intervention and post-intervention questionnaire responses using the available aggregate data. Consequently, the influence of variation in workshop participation on the observed differences in knowledge could not be determined.

Study Duration and Timing of Assessments

The study was conducted over a six-month period, which included ethical approval processing, baseline questionnaire administration, delivery of the educational workshop and post-intervention questionnaire collection. Two months were allocated to obtaining ethical approval, followed by two months for baseline questionnaire collection. The educational workshop was subsequently conducted and the post-intervention questionnaire was collected over a further two-month period. However, the exact interval between workshop attendance and questionnaire completion was not documented in the available study records. Therefore, the post-intervention assessment could not be classified as an immediate or delayed assessment of knowledge retention.

Ethical Approval

Ethical clearance was obtained from the Ethical Committee Board of Al-Baha University, Saudi Arabia. Participation was voluntary and anonymous.

Data Analysis

Questionnaire responses were summarized using frequencies and percentages. The proportions of correct responses were calculated separately for the pre-intervention (n = 81) and post-intervention (n = 69) assessments. Differences between the two assessments were expressed as absolute percentage-point changes. The analysis focused on knowledge of antibiotic indications, antibiotic selection, treatment duration and antimicrobial resistance.

The study evaluated several questionnaire-based knowledge outcomes across antibiotic indications, antibiotic selection, treatment duration and antimicrobial resistance awareness. These outcomes were considered exploratory and no single primary outcome was prespecified in the available study documentation. Because the relationship between the pre-intervention and post-intervention observations remained unconfirmed, inferential hypothesis testing was not included in the revised analysis. Accordingly, no multiple-comparison adjustment was applied. The observed differences were interpreted descriptively and were not used to establish statistical significance.

As individual-level matching between the pre-intervention and post-intervention responses could not be established from the available aggregate data, the comparisons were treated as descriptive. Inferential statistical testing was not undertaken in the revised analysis because the dependence structure of the observations remained undetermined. Consequently, no conclusions regarding statistical significance were drawn from the observed differences. The results were interpreted as exploratory findings of an uncontrolled educational intervention study.

Participant Matching and Response Comparability

The pre-intervention and post-intervention questionnaires yielded 81 and 69 responses, respectively. The available aggregate dataset did not establish whether individual responses could be linked across the two assessments using anonymous participant identifiers. Consequently, participant-level matching and the number of students completing both assessments could not be confirmed. Comparisons between assessments were therefore restricted to descriptive differences in the proportions of correct questionnaire responses until the underlying response records could be examined. No assumption of paired or independent observations was made.

The magnitude of the observed differences between the pre-intervention and post-intervention assessments was summarized using absolute percentage-point changes in correct-response proportions. These descriptive differences were calculated by subtracting the pre-intervention percentage from the corresponding post-intervention percentage for each questionnaire item. Because individual-level matching between assessments could not be established, confidence intervals for within-participant changes and paired effect-size estimates were not calculated. The reported percentage-point differences were interpreted as descriptive measures of change between the two assessments rather than estimates of a confirmed intervention effect.

Intervention Fidelity and Workshop Participation

The educational intervention was delivered as a structured workshop focusing on evidence-based antibiotic prescribing in endodontic practice. The available study documentation did not establish the total number of students who attended the workshop, whether attendance was mandatory or whether all participants received identical educational exposure. Furthermore, workshop attendance could not be linked to individual pre-intervention and post-intervention questionnaire responses using the available aggregate data. Consequently, the influence of variation in workshop participation on the observed differences in knowledge could not be determined.

Consistency with Endodontic Antibiotic Guidelines

International endodontic guidance emphasizes that systemic antibiotic therapy is not routinely indicated for most localized pulpal and periapical conditions when definitive dental treatment is available. Antibiotics may be appropriate as adjunctive therapy in selected cases involving systemic manifestations, progressive infection or other clinically relevant risk factors [4,5,17]. The interpretation of antibiotic-selection knowledge also requires consideration of antimicrobial spectrum, treatment response, allergy history and adverse-effect risks. Therefore, questionnaire responses concerning amoxicillin, amoxicillin-clavulanate and clindamycin cannot be considered universally correct without reference to the clinical circumstances described in the original questions. The study's findings should be interpreted in relation to the specific guideline versions used during the educational intervention, while recognizing that antimicrobial-stewardship recommendations require periodic review as evidence evolves.

RESULTS

Participant Overview

A total of 81 students completed the baseline questionnaire and 69 completed the post-intervention questionnaire. All participants were male clinical-level dental students or interns.

The distribution of participants across academic levels is presented in Table 1. Questionnaire responses concerning antibiotic indications, antibiotic selection and antimicrobial-stewardship knowledge are summarized in Table 2-4 and illustrated in Figure 1-3, respectively. The figures provide descriptive comparisons of the proportions of responses originally classified as correct at baseline and after the educational workshop. The baseline and post-intervention denominators were 81 and 69, respectively. These comparisons do not establish individual-level improvement or a causal effect of the educational intervention.

Table 1 Finding

The baseline assessment included 81 questionnaire responses, whereas the post-intervention assessment included 69 responses, representing a reduction of 12 responses (14.8%) relative to the baseline response count. This reduction was observed across the academic levels. However, individual-level participant matching between the two assessments has not been established. Therefore, the difference in response counts cannot be interpreted as confirmed participant attrition and a comparison between

Table 1: Distribution of Study Participants by Academic Year

Academic Level	Eligible Students	Pre-Workshop Respondents		Post-Workshop Respondents	
		Percentage	No.	Percentage	No.
Fourth Year	25	92	23	76	19
Fifth Year	31	90	28	77	24
Sixth Year	23	82.6	19	69.5	16
Interns	11	100	11	90.9	10
Total	97	83.5	81	71	69

Table 2: Comparison of Correct Antibiotic Decisions for Endodontic Conditions Before and After the Educational Intervention

Clinical condition	Pre n/81 (%)	Post n/69 (%)	Difference (pp)
Irreversible pulpitis	25 (30.9)	57 (82.6)	+51.7
Localized apical abscess without systemic signs	23 (28.4)	55 (79.7)	+51.3
Apical abscess with fever/swelling	44 (54.3)	63 (91.3)	+37.0
Chronic apical periodontitis	29 (35.8)	59 (85.5)	+49.7

pp: Percentage points, Percentages recalculated from the manuscript's reported counts, The correctness of clinical answer keys remains subject to questionnaire and guideline verification, No inferential significance is claimed

Table 3: Comparison of Antibiotic-Selection Knowledge Before and After the Educational Intervention

Antibiotic-selection item	Pre n/81 (%)	Post n/69 (%)	Difference (pp)
Amoxicillin as first-line agent	42 (51.9)	61 (88.4)	+36.6
Amoxicillin-clavulanate for resistant infection	32 (39.5)	58 (84.1)	+44.6
Clindamycin for penicillin-allergic patients	27 (33.3)	56 (81.2)	+47.8

Table 4: Comparison of Antimicrobial Resistance Awareness and Treatment-Duration Knowledge Before and After the Educational Intervention

Knowledge domain	Pre n/81 (%)	Post n/69 (%)	Difference (pp)
Awareness of global AMR	36 (44.4)	63 (91.3)	+46.9
Appropriate antibiotic duration	24 (29.6)	57 (82.6)	+53.0
Consequences of antibiotic misuse	33 (40.7)	61 (88.4)	+47.7

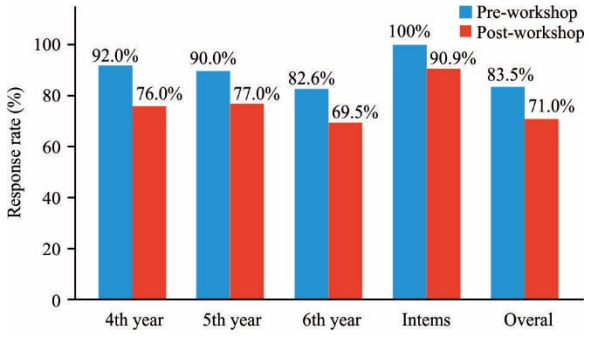


Figure 1: Questionnaire Responses Concerning Antibiotic Indications for Endodontic Conditions Before and After the Educational Workshop

Bars represent the percentages of responses originally classified as correct for each endodontic condition, The baseline assessment included 81 respondents and the post-intervention assessment included 69 respondents, Percentages were calculated using the corresponding assessment denominator, The figures represent descriptive comparisons of questionnaire responses and do not establish individual-level changes

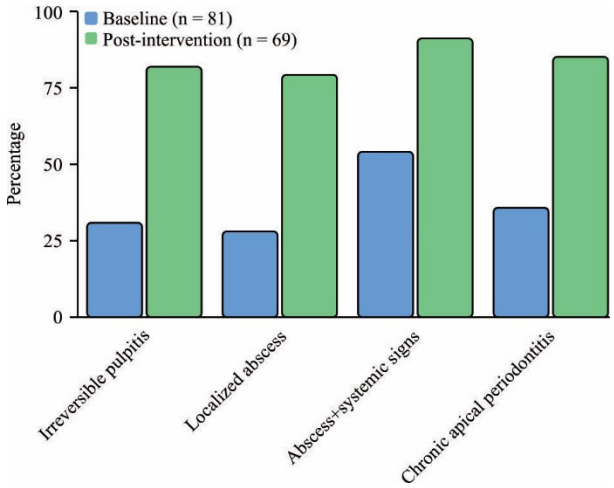


Figure 2: Questionnaire Responses Concerning Antibiotic Selection Before and After the Educational Workshop

Bars represent the percentages of responses originally classified as correct for amoxicillin, amoxicillin-clavulanate and clindamycin selection, The baseline and post-intervention denominators were 81 and 69, respectively, The appropriateness of the original response classifications requires verification against the administered clinical scenarios and guideline-based answer key

students who completed both assessments and those who did not could not be performed using the available aggregate data.

Pre-workshop response rates were high across all academic levels, ranging from 82.6% among sixth-year students to 100% among interns, with fourth- and fifth-year students also demonstrating strong initial participation at 92% and 90%, respectively. However, post-workshop response rates decreased across all groups, with the highest participation observed among interns (90.9%) and the lowest among sixth-year students (69.5%), while fourth- and fifth-year students showed comparable post-workshop response rates of 76% and 77%, respectively (Figure 1).

The number of questionnaire responses decreased from 81 at baseline to 69 at the post-intervention assessment, representing 12 fewer responses (14.8% relative to the baseline count). Lower response counts were observed across all academic levels. The reasons for this reduction were not documented in the available study data. Furthermore, because individual-level matching between the two assessments was not confirmed, the reduction could not be classified as verified participant attrition.

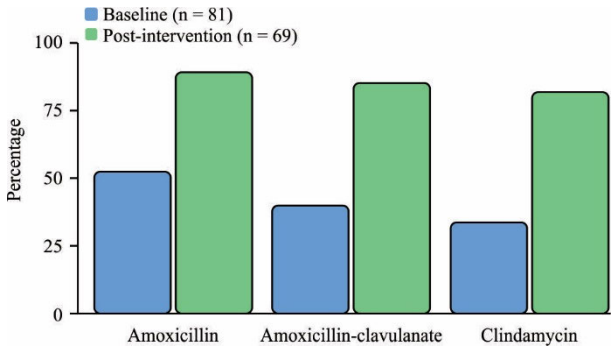


Figure 3: Questionnaire Responses Concerning Antimicrobial Resistance Awareness and Antibiotic-Stewardship Knowledge Before and After the Educational Workshop

Bars represent the percentages of responses originally classified as correct for antimicrobial resistance awareness, antibiotic treatment duration and consequences of antibiotic misuse, The baseline assessment included 81 respondents and the post-intervention assessment included 69 respondents, The displayed values are descriptive and do not imply causal effects or sustained knowledge retention

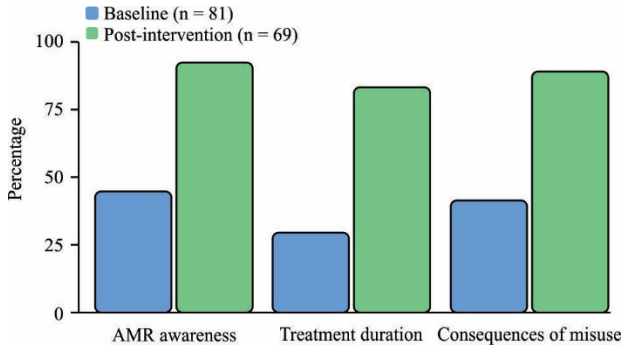


Figure 4: Improvement in Student Foundational Knowledge of AMR

Table 2 Findings

The proportion of correct responses increased across all four assessed endodontic conditions following the educational intervention. The largest descriptive increase was observed for irreversible pulpitis (51.7 percentage points), followed by localized apical abscess without systemic involvement (51.3 percentage points), chronic apical periodontitis (49.7 percentage points) and apical abscess with fever or swelling (37.0 percentage points). These differences indicate improved questionnaire-based recognition of antibiotic indications at the post-intervention assessment. However, their statistical significance was not determined because individual-level matching between assessments remained unconfirmed.

The pre-intervention and post-intervention assessments included 81 and 69 questionnaire responses, respectively. As the available aggregate data did not establish whether individual responses were paired or independent, formal inferential comparisons were not performed. Changes in correct-response proportions were summarized descriptively for each clinical condition. The observed differences indicated higher proportions of correct responses following the educational workshop; however, statistical significance could not be established without clarification of participant matching and reanalysis of the original questionnaire data.

The statistical analysis revealed a highly significant improvement in knowledge across all assessed endodontic conditions (all $p<0.001$), with knowledge regarding irreversible pulpitis rising from 30.8 to 83.5% and localized apical abscess without systemic signs improving from 28 to 79.7%. The highest level of post-workshop proficiency was recorded for apical abscess with fever/swelling, which reached 91% from a baseline of 54%, while knowledge of chronic apical periodontitis increased from 35.8 to 85.5%. Collectively, the post-intervention assessment demonstrated higher proportions of correct questionnaire responses across the evaluated clinical conditions. As multiple knowledge domains were assessed and formal inferential testing was not undertaken, these findings were interpreted as exploratory descriptive differences rather than statistically confirmed effects of the educational intervention. (Figure 2).

Higher proportions of responses classified as correct were observed after the educational workshop across all three antibiotic-selection items. The proportion selecting amoxicillin as the first-line agent increased from 51.9% to 88.4%, representing a difference of 36.6 percentage points. Responses classified as correct for amoxicillin-clavulanate and clindamycin increased by 44.6 and 47.8 percentage points, respectively. These findings represent descriptive changes in questionnaire responses and do not establish statistically significant improvement or clinical prescribing competence.

Similarly, knowledge of the appropriate use of amoxicillin-clavulanate for resistant infections improved significantly, rising from 39.5% (32/81) before the intervention to 84.1% (58/69) afterward ($p<0.001$). In addition, correct selection of clindamycin for patients with penicillin allergy increased from 33.3% (27/81) in the pre-workshop to 81.2% (56/69) in the post-workshop, representing a highly significant improvement ($p<0.001$). Overall, these findings demonstrate that the intervention was associated with substantial and statistically significant gains in students' knowledge of appropriate antibiotic selection (Figure 3).

The baseline assessment identified gaps in questionnaire-based knowledge concerning antibiotic selection and the management of patients reporting penicillin allergy. Higher proportions of responses originally classified as correct were observed at the post-intervention assessment. However, the clinical appropriateness of individual antibiotic choices requires verification against the original questionnaire scenarios and relevant prescribing guidance.

Post-intervention questionnaire responses showed higher proportions of correct answers across the assessed antimicrobial stewardship domains. Knowledge of appropriate antibiotic treatment duration demonstrated the largest descriptive increase (53.0 percentage points), followed by understanding of the consequences of antibiotic misuse (47.7 percentage points) and awareness of global

antimicrobial resistance (46.9 percentage points). These findings suggest improved questionnaire-based knowledge following the educational intervention, although inferential statistical significance was not established.

Awareness of the global antimicrobial resistance problem increased markedly from 44.4% (36/81) in the pre-workshop assessment to 91.3% (63/69) in the post-workshop assessment, with this difference reaching statistical significance ($p<0.001$). Similarly, correct knowledge regarding the appropriate duration of antibiotic therapy improved substantially, rising from 29.6% (24/81) before the workshop to 82.6% (57/69) after the workshop ($p<0.001$). In addition, understanding of the consequences of antibiotic misuse increased from 40.7% (33/81) in the pre-workshop assessment to 88.4% (61/69) in the post-workshop assessment, representing a highly significant improvement ($p<0.001$). Overall, these results indicate that the intervention was highly effective in enhancing students' foundational knowledge related to antimicrobial use and resistance (Figure 4).

Overall Results Summary

The baseline assessment identified gaps in questionnaire-based knowledge of antibiotic indications, antibiotic selection and antimicrobial resistance among the participating dental students. The post-intervention assessment demonstrated higher proportions of responses classified as correct across the evaluated domains. These findings represent differences in questionnaire responses between the two assessment periods and should not be interpreted as evidence of changes in actual antibiotic-prescribing practices. No clinical prescriptions, prescribing records or patient-level treatment decisions were examined in this study. Furthermore, the absence of a control group and the unconfirmed matching of individual respondents between assessments limit conclusions regarding the effect of the educational intervention.

DISCUSSION

This study assessed antibiotic-prescribing knowledge among dental students at Al-Baha University and demonstrated the effectiveness of guideline-focused education in improving rational antibiotic use.

Baseline results revealed considerable misunderstanding of antibiotic indications in endodontic infections. Similar deficiencies have been reported globally among dental students and practitioners [9-12]. Mapping worldwide antibiotic use in dentistry confirms persistent misuse across regions, emphasizing the universal nature of the problem [6,8]. Large observational studies from healthcare systems further confirm that a substantial proportion of dental antibiotic prescriptions remain inappropriate or unnecessary [18-20]. International endodontic guidelines explicitly recommend that systemic antibiotics should not be prescribed for irreversible pulpitis, localized apical abscess or chronic apical periodontitis without systemic involvement [4,5,17]. However, baseline findings in the present study showed that fewer than one-third of students correctly recognized these indications. Comparable knowledge gaps have been documented among Saudi dental students and interns [9,12].

Comparison with Previous Studies

The baseline findings of the present study are consistent with previous questionnaire-based investigations reporting gaps in dental students' knowledge of antibiotic indications, antimicrobial resistance and appropriate antibiotic selection. Cross-sectional studies conducted among dental students and interns in Saudi Arabia have identified variability in knowledge of prescribing guidelines and uncertainty regarding antibiotic use for common dental conditions. These investigations provide useful contextual evidence regarding the educational needs of dental trainees. However, because they assessed participants at a single time point, their findings cannot establish the effectiveness of educational interventions.

Educational intervention studies address a different research question by examining knowledge or other outcomes before and after a defined teaching activity. Such studies may identify changes in assessment scores following educational exposure, although the strength of causal inference depends on their methodological design, including the presence of a comparison group, the validity of the assessment instrument and the ability to account for repeated measurements. The present study similarly demonstrated higher proportions of responses classified as correct during the post-intervention assessment. Nevertheless, the absence of a control group and unconfirmed participant-level matching prevent definitive attribution of these differences to the workshop.

Comparisons between the present findings and previous investigations should also account for differences in participant characteristics, academic level, questionnaire content, clinical scenarios, scoring procedures and timing of assessment. Consequently, the numerical differences observed in the present study should not be directly equated with knowledge scores or prescribing outcomes reported elsewhere. Taken together, the available literature supports the importance of incorporating evidence-based antibiotic stewardship into dental education, while highlighting the need for controlled evaluations that examine both knowledge acquisition and actual clinical prescribing.

For the questionnaire item concerning clindamycin selection in patients with penicillin allergy, responses originally classified as correct were recorded in 27 of 81 students (33.3%) at baseline and 56 of 69 students (81.2%) after the intervention. However, the appropriateness of clindamycin depends on the nature of the reported allergy, the clinical indication for systemic antibiotic therapy and the guideline recommendations applicable to the specific scenario. The original question and scoring criteria were not available for verification. Therefore, these findings were retained as descriptive questionnaire results and were not interpreted as evidence that clindamycin is universally appropriate for penicillin-allergic patients. Antibiotic selection in patients reporting penicillin allergy requires

careful evaluation of the allergy history, severity of previous reactions, indication for antimicrobial treatment and potential adverse effects. The AAE guidance cited in the manuscript recognizes the risks associated with systemic antibiotic administration, including antibiotic-associated Clostridioides difficile infection [17]. Although older endodontic recommendations included clindamycin as a possible alternative in patients with penicillin allergy, its adverse-effect profile requires particular caution. The questionnaire item concerning clindamycin should therefore be evaluated against the exact clinical scenario and the guideline version used during the workshop. Without these details, the recorded responses cannot establish guideline-concordant antibiotic selection.

Awareness of antimicrobial resistance improved markedly following intervention. Global surveillance reports warn that continued misuse of antibiotics will escalate resistance rates worldwide [1,16]. Educating future prescribers remains one of the most sustainable strategies for combating this threat.

The post-intervention assessment demonstrated higher proportions of correct questionnaire responses across the evaluated domains of antibiotic-prescribing knowledge. However, the study employed an uncontrolled pre-post design without a non-intervention comparison group. Consequently, the observed differences cannot be attributed exclusively to the educational workshop. Other influences, including concurrent academic learning, independent exposure to prescribing guidelines and differences in the composition of respondents between assessments, cannot be excluded. The findings should therefore be interpreted as descriptive changes in questionnaire-based knowledge associated with the assessment period rather than evidence of a causal intervention effect. The observed differences in questionnaire-based knowledge following the educational intervention should be interpreted within the limitations of the study design. Although higher proportions of correct responses were recorded during the post-intervention assessment, the study did not include a documented long-term follow-up assessment to determine whether these differences were sustained. Furthermore, actual antibiotic prescriptions issued by the participants were not evaluated. Therefore, the findings cannot establish long-term knowledge retention or changes in clinical prescribing behavior. Future studies should incorporate repeated assessments at predefined intervals and objective evaluations of prescribing decisions in clinical settings to determine whether educational gains are maintained and translated into appropriate antibiotic use.

No non-intervention comparison group was included. Accordingly, the study design permitted description of pre-intervention and post-intervention questionnaire responses but did not permit definitive causal attribution of the observed differences to the educational workshop.

The post-intervention assessment demonstrated higher proportions of questionnaire responses classified as correct across the evaluated domains of antibiotic indications, antibiotic selection and antimicrobial resistance. These findings suggest differences in knowledge-based responses between the two assessment periods. However, questionnaire performance should be distinguished from actual prescribing behavior. The present study did not include prescription audits, clinical prescribing records or direct observation of antibiotic selection during patient care. Therefore, the observed differences cannot establish whether students subsequently prescribed antibiotics more appropriately in clinical practice. Previous educational studies may provide a rationale for incorporating antimicrobial-stewardship training into dental curricula but the clinical effectiveness of such training requires evaluation using objective prescribing outcomes [13-18].

Saudi Arabia's national antimicrobial stewardship initiatives encourage healthcare institutions to promote rational antibiotic use. Dental schools play a vital role in supporting these national policies by producing graduates equipped with evidence-based prescribing competence [9,12,18].

Overall, the study confirms that guideline-focused education significantly enhances antibiotic-prescribing knowledge and attitudes among dental students, supporting curricular reforms toward sustainable stewardship practices.

CONCLUSIONS

The present study identified gaps in questionnaire-based knowledge of antibiotic indications, antibiotic selection and antimicrobial resistance among clinical-level dental students at Al-Baha University. Higher proportions of responses classified as correct were observed following the guideline-based educational workshop across the evaluated knowledge domains. These findings suggest that structured educational activities may have a role in reinforcing antimicrobial-stewardship principles during undergraduate dental training.

However, the absence of a control group, uncertainty regarding participant-level matching and limitations in questionnaire documentation restrict conclusions about the effectiveness of the intervention. The study did not evaluate actual antibiotic prescriptions or long-term knowledge retention. Consequently, the observed findings cannot establish whether the workshop resulted in sustained improvements in clinical prescribing or reduced inappropriate antibiotic use. Further controlled studies using validated assessment instruments, longer follow-up periods and objective prescribing outcomes are recommended.

Limitations

The present study has several limitations that should be considered when interpreting its findings. First, the investigation was conducted at a single dental institution and included only male clinical-level dental students and interns. The inclusion of male participants reflected the institutional arrangements under which the study was conducted. Nevertheless, the restricted setting and participant characteristics limit the generalizability of the findings to female students, other dental institutions and broader student populations.

Second, the study included a relatively small number of respondents, with 81 students completing the baseline

questionnaire and 69 completing the post-intervention assessment. The smaller post-intervention response count may have influenced the observed distribution of responses. However, individual-level matching between the two assessments was not confirmed and it was therefore not possible to determine whether the difference in response counts represented withdrawal of specific participants or differences in questionnaire participation. Comparisons between respondents who completed both assessments and those who did not could not be performed from the available information. Furthermore, the total eligible population reported in the manuscript was inconsistent with the sum of the eligible students listed across academic levels, preventing confirmation of the overall response rates until the recruitment records are reconciled.

Third, the uncontrolled pre-post design limits causal inference. Without a non-intervention comparison group, changes in questionnaire responses cannot be attributed exclusively to the educational workshop. Concurrent academic instruction, independent learning, repeated exposure to assessment questions and differences in respondent composition may have contributed to the observed findings. The absence of verified participant-level matching also limits the selection and interpretation of appropriate paired statistical analyses. Consequently, the reported findings were interpreted descriptively rather than as definitive evidence of intervention effectiveness.

Fourth, the outcomes were based on questionnaire responses, making the findings potentially susceptible to response bias, recall effects and socially desirable answers. The available study documentation did not establish the questionnaire's content validity, reliability, pilot-testing procedures or complete scoring criteria. In addition, the exact clinical scenarios and answer keys for certain antibiotic-selection items were not available for verification. These limitations affect the interpretation of responses classified as correct and the extent to which the questionnaire measured guideline-concordant knowledge.

Fifth, the available documentation did not establish the precise interval between the educational workshop and each participant's post-intervention assessment. This limits interpretation of the findings in relation to immediate learning and subsequent knowledge retention. No long-term follow-up assessment was documented and the study could not determine whether any observed differences persisted over time. Information sufficient to evaluate workshop attendance and consistency of intervention delivery across participants was also unavailable.

Finally, the study assessed questionnaire-based knowledge rather than actual clinical antibiotic prescribing. No prescription audits, patient-level treatment records or direct observations of clinical prescribing decisions were undertaken. Therefore, the findings cannot establish whether the educational workshop reduced inappropriate antibiotic use or improved patient care. Future multicenter controlled studies involving diverse student populations, validated assessment instruments, verified participant follow-up, predefined assessment intervals and objective prescribing outcomes are warranted.

Ethical Approval

The manuscript reports that ethical clearance was obtained from the Ethical Committee Board of Al-Baha University, Saudi Arabia. Participation in the questionnaire assessments was voluntary and anonymous, as reported in the original study documentation.

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