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Amna Faisal

amnafaisal.dental@hitec-ims.edu.pk

National University Of Medical Sciences

Samia Shafiq

Quaid e Azam University

Abdullah Bin Zubair

National University Of Medical Sciences

Rabbia Ashraf

University of Child Health Sciences

Research Article

Keywords: dental education, research module, dentistry, research skills, evidence-based dentistry

Posted Date: September 16th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10534982/v1

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Additional Declarations: No competing interests reported.

Evaluating The Impact Of A Structured Research Module On Research-Related Learning Outcomes Among Second-Year Dental Students: A Quasi-Experimental Pre-Post Study

Amna Faisal[1*], Samia Shafiq[2†], Abdullah Bin Zubair[1], Rabbia Ashraf[4†]

[1*]Community Dentistry, Dental College, Hitec IMS, National University Of Medical Sciences , ,Rawalpindi, Pakistan.
[2]Mphil Psychology, Quaid e Azam University, Islamabad, Pakistan.
[3]Clinical Psyhologist,University of Child Health Sciences, Childrens Hospital, Lahore, Pakistan.

*Corresponding author(s). E-mail(s): amnafaisal.dental@hitec-ims.edu.pk;
Contributing authors: samiashafiq88@gmail.com; abdullahbinzubair.dental@hitecims.edu.pk; rabbiaashraf14@gmail.com;
†These authors contributed equally to this work.

Abstract

Background: Research training is essential in undergraduate dental education because it supports evidence-based practice and prepares students for academic and clinical decision-making. This study assessed the effect of a structured research module on research-related knowledge, skills, attitudes, and practical performance among second-year BDS students.

Methods: A quasi-experimental single-group pre-test post-test study was conducted among 46 second-year BDS students at Dental College, HITEC-IMS, Pakistan (from August to November 2025). The research module was delivered over 11 weeks through weekly two-hour sessions. Data were collected before and after the intervention using a research-related knowledge, skills and attitude

questionnaire, an attitude toward research training questionnaire, and an Objective Structured Practical Examination. Paired-samples t-tests and the Wilcoxon signed-rank test were used for analysis.
Results: Post-intervention assessments revealed statistically significant improvements across all measured domains. Mean knowledge scores increased from 5.09 to 6.43 (p = 0.017), and self-reported skills improved from 13.59 to 16.04 (p = 0.016). Total research attitude scores also significantly improved (p = .002). Practical research performance showed the largest improvement, with median OSPE scores increasing from 11.00 to 61.00, p ¡ 0.001.
Conclusions: The structured research module was associated with improved research-related knowledge, skills, attitudes, and practical performance among second-year dental students. Early integration of structured research teaching in the BDS curriculum may help strengthen students' research competence and readiness for evidence-based dental practice. .

Keywords: dental education, research module, dentistry, research skills, evidence-based dentistry

1 Introduction

Research competency has become an essential component of modern dental education because dental graduates are expected to move beyond passive acquisition of theoretical and clinical knowledge toward evidence-informed decision-making [1]. Clinicians require critical thinking skills, knowledge of research methods, and the ability to apply research findings in real-world clinical situations. Connecting professional expertise and patient preferences with high-quality evidence is central to evidence-based dentistry; therefore, undergraduate dental education should include teaching on the interpretation and application of research findings [2,3].

Undergraduate research training provides students with a foundation for understanding scientific questions in a scholarly manner [4]. These skills support critical thinking, problem-solving, and evidence-based clinical decision-making. Research exposure during dental undergraduate education can improve student confidence, academic participation, and readiness for postgraduate education or future scholarly work [5]. Long-term evidence from a dental undergraduate research training program has shown that structured research exposure can support academic achievement and professional development among dental graduates [6]. Similarly, the development of research skills has been associated with the ability of graduates to transfer evidence-based practice behaviors from university learning to clinical employment settings [7].

Recent reviews and curriculum-based studies further support the need for formal research training in dental education. Liu et al. [4], reported that undergraduate dental basic research education is widely regarded as important for cultivating scientific research capability. Their research found out that mentor-guided student research projects, classroom-based instruction, and practical training in research techniques. At the same time some challenges were also highlighted such as curriculum burden,

limited qualified teachers, lack of financial support, and lack of research knowledge and skills. The findings indicate that although research education is known as an important factor of dental training, further steps are required to build clear learning objectives, create more structured educational frameworks, and implement effective evaluation methods for assessment of student learning outcomes.

Many studies show that dental students generally support research and evidence-based dentistry. Amir et al. [8] found that most clinical students supported undergraduate research as a dentistry curriculum requirement and perceived it as advantageous for professional growth. Rath et al. [9] reported that undergraduate dental students supported evidence-based dentistry but had mixed confidence in critical appraisal and practice. Juhari et al. [10] also found that Malaysian undergraduate dentistry students had positive attitudes toward research, while emphasizing the need for supervision, training, and academic support to increase student engagement.

Despite this favorable attitude, actual participation in research remains limited in many dental education settings. Vishwanathaiah et al. [11] reported that although most undergraduate dental students and interns recognized the importance of research and expressed interest in future research activity, a large proportion had not conducted research during their undergraduate course.

Similar concerns have been reported in the evidence-based dentistry literature, where students may demonstrate positive attitudes but lack adequate knowledge, access skills, confidence, or practical ability to appraise and apply scientific evidence [12, 13]. Wadgave et al. [14] conducted a pre-post experimental study among undergraduate dental students and found that evidence-based practice training improved students' knowledge, attitudes, evidence-accessing methods, and confidence in critical appraisal.

In Pakistan, Mumtaz and Sabir [15] introduced journal clubs to preclinical dental students and reported significant improvement in evidence-based medicine competency scores following the intervention. Earlier work by Azarpazhooh et al. [16] also showed that a module on evidence-based decision-making helped dental students improve their ability to clinical research practice.

Although existing literature supports the value of research training and evidence-based dentistry in undergraduate dental education, important gaps remain in how these competencies are taught and evaluated. Previous studies have shown that dental students generally demonstrate favourable attitudes toward research and evidence-based dentistry, yet their confidence in critical appraisal, manuscript writing, practical research participation, and routine application of evidence remains variable [8, 9, 11]. Intervention-based studies have also reported improvements in students' evidence-based practice knowledge, attitudes, information-seeking ability, and critical appraisal skills following structured workshops, journal clubs, and evidence-based decision-making modules [14-16]. Similarly, evidence from systematic and scoping reviews suggests that undergraduate dental research education and evidence-based dentistry interventions can increase students' perceived and actual knowledge; however, current evidence is limited by variation in instructional techniques, outcome measures, research designs, and methodological rigour [3, 4, 17].

Most available literature has focused mainly on students' views, attitudes, and perceived barriers concerning evidence-based dentistry, with fewer studies examining improvements in applied research learning outcomes before and after interventions. In addition, many interventions have been delivered to clinical-year students, interns, or senior undergraduates; therefore, evidence remains limited on the impact of structured research training during the early foundational years of dental school. The introduction of a structured research module in the second year of the BDS programme addresses this gap and is pedagogically purposeful. This phase is a formative period in students' cognitive and academic development, during which students begin moving from rote memorisation of basic sciences toward higher-order analytical thinking and scientific reasoning. Placing research methodology before the greater cognitive and time demands of clinical training allows educators to integrate research learning with these developmental milestones. Therefore, the present study was conducted to evaluate the effect of a structured research module on the learning outcomes of second-year BDS students in terms of research knowledge, skills, attitudes, and practical performance.

2 Methods

2.1 Study Design

A quasi-experimental single-group pre-post-test design was used. The study was conducted in the Department of Community Dentistry, Dental College, HITEC-IMS, Pakistan, from August to November 2025.

2.2 Study participants

G*Power software was used to estimate sample size a priori, following power analysis guidelines for behavioral and health sciences research [18, 19]. The study compared students' pre- and post-intervention scores using a paired-samples approach. With a two-tailed test, alpha level of 0.05, statistical power of 0.80, and an expected small-to-moderate effect size of dz = 0.39-0.40, 52-54 participants were calculated as the minimum required sample size.

The participants were 2nd year BDS students enrolled in the Community Dentistry course during the study period. Students were eligible for inclusion if they were enrolled in second-year BDS, were present during the study period, gave consent to participate, and completed both pre-intervention and post-intervention assessments. Both male and female of age above 19 year were included. Students who did not respond, submitted incomplete responses, were absent from either assessment, or left the class during the study period were excluded from the final analysis. Convenient sample strategy was used. The study was conducted in an intact class-based educational setting, where the accessible population was smaller than the calculated sample size. In addition, a few students did not respond, submitted incomplete responses, or left the class during the study period. Therefore, all available students with complete paired pre-test and post-test data were included in the final analysis. The achieved final sample size was 46 students.

2.3 Participant characteristics

The mean age of the participants was 21 years. The majority of participants were female (n = 40, 87.0%) (Tab. 1).Characteristics of the participants are summarized in Table 1. Most participants reported no previous research experience (n = 30, 65.2%), and only 10.9% reported previous research experience. Similarly, most participants had not previously attended any research-related course (n = 37, 80.4%).

Table 1 Characteristics of the participants

Characteristic	Frequency	Percentage
Male	70	46.7
Female	80	53.3

2.4 Research module

The educational intervention was based on the published and validated "Module for Undergraduate Medical Research" developed by Sidhu et al. [20]. The original module was developed at Adesh Institute of Medical Sciences and Research, Bathinda, Punjab, India, through a participatory action research approach and mixed-methods design. It underwent internal and external expert validation and demonstrated high face validity and strong content validity, with an overall content validity index of 0.975. The module was also pilot tested by the original authors among undergraduate medical students and interns and showed significant improvement in research-related knowledge and skills after delivery [20].

2.5 Intervention delivery

In the present study, the adapted module was delivered over 11 weeks, with one two-hour session per week. The total teaching duration was 22 hours. The sessions were conducted from August to November 2025. The teaching content are presented in Additional file 1 "(See Additional file 1"). The module was delivered by second-year BDS Community Dentistry faculty at Dental College, HITEC-IMS. The teachers had postgraduate qualifications, multiple years of teaching experience, and practical work and research experience. The teachers who delivered the module were not involved in OSPE assessment.

2.6 Instruments

Three assessment tools were used to evaluate the outcomes of the research module.

The researcher-developed KSA questionnaire was used to assess students' research-related knowledge, self-reported skills, and attitudes before and after the intervention "(See Additional file 2"). The knowledge component consisted of 10 items scored as correct or incorrect, with possible scores ranging from 0 to 10. Higher scores indicated

better research knowledge. The knowledge test was treated as a content-based assessment because the items covered multiple domains of research knowledge rather than a single unidimensional construct.

The skills component of the KSA questionnaire contained five self-report items rated on a five-point Likert scale. Total scores ranged from 5 to 25, with higher scores indicating greater perceived research skills. The items assessed students' confidence and perceived ability in research-related tasks, such as identifying a research problem, understanding research design, interpreting data, and applying research concepts in academic work. In the present study, the skills scale showed acceptable to good internal consistency, with Cronbach's alpha values of 0.840 at pre-test and 0.752 at post-test.

The attitude component consisted of five items rated on a five-point Likert scale. Total scores ranged from 5 to 25, with higher scores indicating a more positive attitude toward research training and engagement. The items assessed students' interest, motivation, perceived importance of research, and willingness to participate in research-related academic activities. It demonstrated good to excellent internal consistency, with Cronbach's alpha values of 0.818 at pre-test and 0.941 at post-test.

The Objective Structured Practical Examination (OSPE) was used to assess students' practical research skills. It included 14 checklist-based items that evaluated students' ability to apply research knowledge in practical tasks, including data handling, analysis, interpretation, and presentation of research-related information "(See Additional file 3"). Higher scores indicated better practical performance. The OSPE was validated by five experts who evaluated its content validity, clarity, relevance, and structure for assessing students' practical research knowledge. After expert approval, the OSPE was administered before and after the module to assess change in students' practical research performance. The OSPE consisted of 14 stations/tasks with a maximum possible score of 70. Each station was allocated four minutes. Of the 14 stations, six were observed stations assessed directly by examiners, while eight were unobserved stations based on written or task-based responses.

The 16-item attitude toward research training questionnaire was used to assess students' perceptions of the research training environment [21, 22]. Responses were recorded on a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. Total scores ranged from 16 to 80, with higher scores indicating more positive attitudes toward research training. In the present study, the questionnaire showed acceptable internal consistency at pre-test (Cronbach's alpha = 0.664) and good internal consistency at post-test (Cronbach's alpha = 0.812).

2.7 Procedures

Before the start of the module, students were informed about the purpose of the study and the assessment process. After consent was obtained, baseline data were collected using the pre-intervention knowledge questionnaire, attitude scale and OSPE. The research module was then delivered over 11 weeks. After completion of the module, students were assessed immediately using the same knowledge questionnaire, attitude scale and OSPE. Post-intervention assessment was conducted within one week after completion of the module. The pre-intervention and post-intervention OSPEs followed the same station structure, time allocation and scoring rubric. A total of 46 students

appeared in the OSPE. Students were divided into three batches to allow smooth conduct of the examination. Six assessors were involved in the pre and post-intervention OSPE. To reduce assessor bias, assessors were blinded to assessment status, and the faculty members who delivered the teaching sessions were not involved in OSPE scoring. Students had no practice exposure to the OSPE before the pre-test. The same OSPE stations, tasks and scoring checklist were used before and immediately after the intervention.

2.8 Statistical analysis

Data were entered and analyzed using SPSS version 30. Normality of pre-test and post-test scores was assessed before selecting inferential tests. Normally distributed paired data were analyzed using paired-samples t-tests. Non-normally distributed paired data were analyzed using the Wilcoxon signed-rank test. A p-value of less than 0.05 was considered statistically significant.

2.9 Ethical considerations

All procedures performed were in accordance with ethical standards of institution research committee and with 1964 Helsinki declaration and its later amendments. Ethical approval was obtained from IRB committee of Dental College Hitec-IMS (Dental/HITEC/IRB/123). Permission to use the research module was obtained from the module developer. Students were informed about the purpose of the study, voluntary participation, confidentiality of responses, and their right to withdraw at any stage without academic penalty. Written informed consent was obtained from all participants before data collection. All data were anonymized before analysis and used only for research purposes. Students' participation or non-participation did not affect their academic evaluation.

3 Results

Pre- and post-intervention comparisons showed statistically significant improvements across all learning outcomes (Fig. 1). Pre- and post-intervention comparison of research learning outcomes is presented in Fig 1. Students' research attitude total scores increased after completion of the research module. The mean score increased from 42.57 ± 7.71 at pre-test to 45.09 ± 10.91 at post-test, $t(45) = -3.28$, $p = 0.002$, with a small-to-moderate effect size (Cohen's $d = 0.33$) Knowledge scores also improved significantly after the intervention. The mean knowledge score increased from 5.09 ± 3.25 at pre-test to 6.43 ± 2.02 at post-test, $t(45) = -2.48$, $p = 0.017$, with a moderate effect size (Cohen's $d = 0.37$).

Students' self-reported skills showed a smaller but statistically significant improvement. The mean skills score increased from 13.59 ± 4.90 at pre-test to 16.04 ± 4.19 at post-test, $t(45) = -2.50$, $p = 0.016$, with a small-to-moderate effect size (Cohen's $d = 0.37$).

The KSA attitude score also showed a statistically significant change. The mean score increased from 19.51 ± 2.94 at pre-test to 20.20 ± 3.52 at post-test, $t(45) = -2.83$,

Table 2 Pre-post comparison of learning outcomes

Outcome	Pre-test	Post-test	Test statistic	p-value	Effect size
Research attitude Scale	42.57 ± 7.71	45.09 ± 10.91	t(45) = -3.28	0.002	d = 0.33
Knowledge	5.09 ± 3.33	6.43 ± 2.02	t(45) = -2.48	0.017	d = 0.37
Skills	13.59 ± 4.90	16.04 ± 4.19	t(45) = -2.50	0.016	d = 0.37
Attitude	19.51 ± 2.94	20.20 ± 3.52	t(45) = -2.83	0.007	d = 0.29
OSPE	11.00, IQR = 7.00	61.00, IQR = 8.50	Z = -5.91	¡ 0.001	r = 0.87

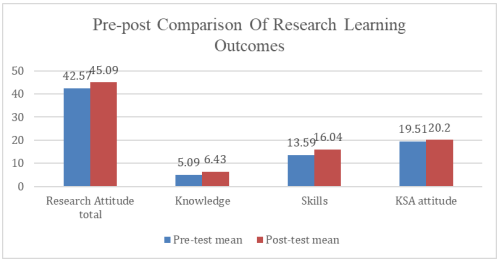


Fig. 1 Figure 1. Pre- and post-intervention comparison of research learning outcomes

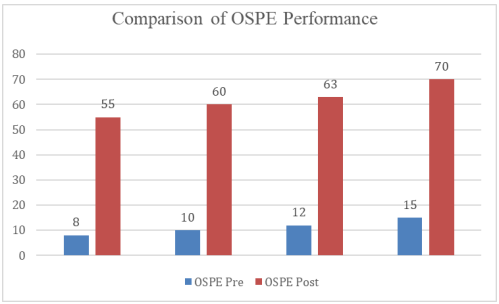


Fig. 2 Figure 2. Pre- and post-intervention comparison of OSPE performance

p = 0.007, with a small effect size (Cohen's d = 0.29) (Tab. 2). Pre-post comparison of learning outcomes is summarized in Table 2.

OSPE scores showed a statistically significant improvement following the research module (Fig. 2). The median OSPE score increased from 11.00 (IQR = 7.00) at pre-test to 61.00 (IQR = 8.50) at post-test. The Wilcoxon signed-rank test showed that this improvement was statistically significant, Z = -5.91, p ¡ 0.001, with a very large effect size (r = 0.87). Pre- and post-intervention comparison of OSPE performance is shown in Figure 2.

Note. ± = standard deviation, IQR= interquartile range.

4 Discussion

Developing research competence among undergraduate dental students is an important educational priority, particularly in curricula that aim to promote evidence-based practice, critical appraisal, and lifelong learning. Existing literature suggests that students generally recognize the value of research in dental education but may have limited practical involvement and variable confidence in applying research skills [11, 23]. Barriers such as insufficient training, limited supervision, lack of time, and inadequate opportunities for active participation may further restrict students' engagement with research [10, 23, 24]. In this context, structured research educational instruction can serve as an important link between theoretical understanding and practical application, especially when research is integrated into the undergraduate curriculum rather than regarded as a separate academic requirement [9, 10]. The current study identified significant increases in overall research learning outcomes from pre- to post-intervention, including total scores on the research questionnaire, knowledge, skills, KSA attitudes, and OSPE performance. While questionnaire-based results showed mild-to-moderate improvements, OSPE performance showed a substantial increase, suggesting stronger gains in applied research skills.

The positive influence on students' overall research attitude scores is a significant finding, as research attitude is frequently regarded as an important factor in student engagement in evidence-based learning, scientific inquiry, and future research work. Prior research suggests that undergraduate dental students acknowledge the significance of research and evidence-based dentistry; however, their engagement is often compromised by inadequate training, low confidence, insufficient guidance, and restricted opportunities for practical involvement [8, 9, 11].

The improvement in attitude scores in the present study may indicate that structured exposure to research helped students perceive research as more relevant, understandable, and connected to their future role as dental professionals. This is consistent with the view that research should be introduced not as an isolated academic requirement, but as a core component of professional dental education and evidence-based practice [2, 3].

The improvement in knowledge scores after the intervention also supports previous evidence that research and evidence-based dentistry teaching can strengthen students' understanding of scientific concepts. Wadgave et al. [14] reported significant improvement in evidence-based practice knowledge among undergraduate dental students after a structured training intervention. Similarly, Mumtaz and Sabir [15] found that introducing journal clubs to preclinical dental students significantly improved evidence-based medicine competency scores. A systematic review by Molena et al. [17] further concluded that educational interventions in evidence-based dentistry generally improve students' perceived and actual knowledge, particularly in the domains of acquiring and appraising evidence. The smaller effect size observed for knowledge in the present study may reflect the short duration of the module, the early academic level of second-year students, or the fact that research knowledge requires repeated exposure and reinforcement across the curriculum.

Students' self-reported research skills also improved significantly, although the magnitude of improvement was small-to-moderate. This is educationally important

because research skills improve through practice, feedback, supervision, and application. Beyond theoretical knowledge, students must learn to search literature, generate research questions, understand methods, interpret findings, and communicate scientific information. In a scoping review of undergraduate dental basic research education, Liu et al. [4] reported that mentor-guided research projects, instructional courses, and practical skill-based training were commonly used approaches, while also noting variation in teaching models and assessment systems. The present findings suggest that early exposure can improve students' perceived research skills, although sustained curricular reinforcement may be required to produce long-term change. Scott et al. [6] similarly reported long-term benefits of sustained undergraduate research training in dental education.

The current study showed a significant improvement in students' KSA attitude scores following the research module, although the effect size was small. This finding has academic significance because attitudes toward research may be more resistant to short-term change than knowledge or practical skills. Previous research has also shown that dental students may hold positive views about research, but these attitudes require structured academic exposure, supervision, and active engagement opportunities to translate into stronger research intentions. Vishwanathaiah et al. [11] found that undergraduate students acknowledged the importance of research and showed interest in future research activity, although actual research participation remained limited.

Similarly, Juhari et al. [10] reported that dental undergraduates were generally supportive of including research within the academic program and perceived research engagement as beneficial for professional development. The small but significant improvement in the present study may therefore suggest that even a focused research module can positively influence students' attitudes when it provides guided exposure to research concepts and activities.

The findings are also consistent with evidence from medical and dental education showing that positive attitudes toward research are linked with supportive learning environments and adequate research training. Kyaw Soe et al. [23] reported that although students had moderate knowledge and attitudes toward scientific research, lack of time, knowledge, skills, funding, and facilities remained important barriers. Similarly, Rath et al. [9] found that formal exposure to evidence-based dentistry and integrated curricula were associated with more positive attitudes and practice. In this context, the improvement in KSA attitude scores may reflect the value of embedding research teaching within undergraduate dental education rather than treating research as an isolated or optional activity.

The substantial improvement in OSPE scores provides strong evidence of improvement in applied performance after the module, not only self-reported learning, although the absence of a control group limits causal interpretation. OSPE is widely used in health professions education because it allows structured assessment of applied skills through standardized tasks and predetermined criteria [25, 26]. The large improvement in OSPE performance in the present study may reflect that students had limited baseline exposure to practical research tasks before the module and therefore benefited substantially from structured instruction and guided practice. This finding is particularly important because performance-based assessment can capture learning

outcomes that may not be fully reflected in written knowledge tests or self-reported skill ratings.

The findings have implications for dentistry curriculum planning. Undergraduate research education should be progressive and competency-based, rather than a separate activity. When structured research modules include defined learning objectives, guided instruction, active learning, and practical evaluation, attitude, knowledge, skills, and OSPE performance may improve significantly. The increases in knowledge and self-reported skills were not as large as the increase in OSPE performance, suggesting that research competence may require repeated exposure across several semesters. Curriculum planners may consider introducing research teaching into the early BDS program and gradually progressing toward literature appraisal, protocol development, data analysis, scientific writing, and presentation in later years. This approach is consistent with recommendations that undergraduate dental research education should include clear goals, structured formats, and assessment methods [4, 17].

The use of a small, single-group sample without a control group limits the generalizability of the findings to a broader student population. Furthermore, students' self-assessments may have been influenced by social desirability bias or a temporary increase in topic awareness immediately following the module. Larger multicenter studies with control groups and extended follow-up are needed to determine whether early academic exposure translates into sustained scholarly engagement and evidence-based clinical practice over time.

5 Conclusion

The findings suggest that a structured research module may improve undergraduate dental students' research-related knowledge, skills, attitudes, and OSPE performance. Although some improvements were modest, the results indicate that structured exposure to research principles and practical activities may strengthen students' engagement with research. Introducing such modules into the undergraduate dental curriculum may support research competence and a more favorable attitude toward evidence-based academic and clinical practice. Future research with larger sample sizes, control groups, and longer follow-up periods should assess the durability of these learning gains.

Declarations

5.1 Ethics approval and consent to participate

Ethical approval was obtained from the Institutional Review Board/Ethics Review Committee of Dental College Hitec-Ims, approval no. Dental/HITEC/IRB/123. Written informed consent was obtained from all participants before data collection.

5.2 Consent for publication

Not applicable.

5.3 Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

5.4 Competing interests

The authors declare that they have no competing interests.

5.5 Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

5.6 Authors' contributions

5.7 AF: Substantially contributed to conception and design, acquisition and analysis/interpretation of data. Drafted and critically revised the manuscript.

5.8 SS: Substantially contributed to conception and design and data acquisition. Revised the manuscript critically for intellectual content.

5.9 AZ: Substantial contributions to the acquisition of data. Provided critical revision of the manuscript.

5.10 RA: Substantially contributed to conception, design, and interpretation of data. Drafted and critically revised the manuscript.

All authors read and approved the final manuscript.

6 Appendix

Additional file 1. Research Module
Additional file 2. KSA Questionnaire
Additional file 3 OSPE

7 Biblography

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