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ORIGINAL ARTICLE

Assessment of metacognition levels: A cross-sectional study among dental professionals in Pakistan

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ABSTRACT

Background: Metacognition plays a pivotal role in learning, particularly in dentistry, enabling individuals to effectively manage their cognitive processes and identify areas for improvement.
Objective: To evaluate the degree of metacognition among dental professionals at various phases of their careers.
Methods: A cross-sectional study was conducted, using a non-probability sampling technique in private dental hospitals of Lahore from April to June 2024. A total of 320 dental professionals consented to participate. Data collection involved a semi-structured questionnaire and the Metacognitive Assessment Inventory (MAI), comprising two overarching domains – knowledge about cognition and regulation of cognition, each with three and five subdomains, respectively. Data were analysed using SPSS version 25. Descriptive statistics were computed, and one-way ANOVA and post hoc analysis were used to evaluate group differences. A p-value of <0.05 was considered statistically significant.
Results: Consultants demonstrated significantly higher total cognitive knowledge scores than house officers (16.4 versus 8.5, respectively). This trend extended across subdomains, including procedural, conditional, and declarative knowledge. Similarly, consultants outperformed other participants in cognitive regulation (32.9 versus 17.6, respectively), particularly in planning and evaluation. Subdomains such as information management, communication, and debugging strategies were significantly higher in consultants than in graduate dentists, house officers, and postgraduates. General dentists had the highest cognition score among all the others (p<0.05).
Conclusion: The metacognition level of consultants and general dentists was highest among dental professionals. It underscores the importance of fostering self-learning among dental professionals, particularly through developing their metacognitive abilities.

Key Words: Metacognition, dentists, metacognitive awareness

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INTRODUCTION

Both graduate and undergraduate academic programs are incredibly competitive and demand exceptional clinical abilities in addition to passing numerous challenging exams.[1] One of the most critical aspects of medical education is self-regulated learning. Students who engage in self-regulated learning must actively set goals, evaluate their performance, and control their motivation, actions, and thought processes.[2, 3]

In the specialized field of dentistry, “metacognition,” which is commonly defined as "the process of contemplating one's thinking," is crucial.[4] The term "metacognition," first used by Flavell in 1976, refers to comprehending and critically analysing one's cognitive processes or learning strategies.[4]

Metacognitive knowledge and metacognitive control are the two core components of metacognition.[5] Declarative, procedural, and conditional knowledge are components of metacognitive knowledge, which is knowing ourselves—our thought processes, methods for approaching problems, and the circumstances in which we function most effectively. On the other hand, the active regulation and management of cognitive processes during tasks is known as metacognitive control. This entails planning our strategy, monitoring our understanding while working on a task, evaluating our output, handling the pertinent data, and troubleshooting or correcting errors as they occur.[6]

Because of its connection to students' self-motivation and the effectiveness of mentorship, metacognition is becoming increasingly crucial in dental education.[7] Mentors use various methods, each with significant variations, to assist students in developing their metacognitive awareness.[8] Since reflective inquiry is based on the Socratic method, which has its roots in ancient Greece, students' self-motivation has increased. Using reflective inquiry to enhance students' learning is one way to promote their self-motivation.[9]

Teaching students metacognitive strategies enhances their learning outcomes and helps them build critical thinking abilities essential for clinical practice.[10] Dentists frequently handle complex cases that necessitate the consideration of several elements, including patient history, clinical observations, and available treatments, to make well-informed treatment decisions.[11] Studies show that health workers with good metacognition abilities may handle complexity and uncertainty more effectively in clinical settings.[12] Research suggests that cultural intelligence and communication skills are shaped by reflective learning and real-world patient interactions, key metacognition aspects.[13] Enhanced metacognitive skills are known to improve diagnostic accuracy and aid in identifying concealed illness.[14] Furthermore, metacognition equips professionals with the proactive learning and problem-solving skills necessary to adapt to the evolving needs of their patients effectively.

Despite its importance, limited research has been done on how dental professionals' metacognitive skills vary depending on where they are in their careers. Moreover, previously mentioned studies lack specificity, are either limited to student populations, or do not clearly distinguish between professional categories, i.e., house officers (HO), postgraduate residents (PGR), and general dentists (GD). Therefore, this study was conducted to fill this gap by clearly focusing on practicing dental professionals, not just students.

The objective was to evaluate the degree of metacognition among dental professionals at various phases of their careers. It examined how metacognitive knowledge and regulation vary across different stages of professional development. Utilizing the Metacognitive Awareness Inventory (MAI), this study offers practical insights into how clinical experience shapes metacognitive abilities and highlights key areas where targeted training and educational improvements can be introduced.

METHODS

It was a cross-sectional study, conducted in four private dental hospitals of Lahore, Pakistan, from April to June 2024. Ethical approval was obtained from the institutional ethical review committee before data collection. Informed consent was obtained from all participants. The purpose of the study, the voluntary nature of participation, the assurance of confidentiality, and the anonymity of responses were clearly explained on the first page of the Google Form. Dental professionals who were working in private dental hospitals, including HO with a completed six months experience, PG trainees with a completed two years FCPS training, GD, a licenced dental practitioner with at least two years working in the same capacity, and consultants with two years of experience after post-graduation, who consented to participate and completed the questionnaire in full, were included in the study. In contrast, incomplete responses, non-consenting individuals, and dental professionals from institutions other than private dental hospitals were excluded. A sample size of 273 was calculated with a 95% confidence level and a 5% margin of error, and 23% was taken as a good MAI score using the formula for proportions with the WHO sample size calculator.[7] However, we collected responses from 320 dental professionals over three months, increasing our findings' statistical power and representativeness. The participants were divided into four groups: HO, PGR, GD, and consultants. A non-probability purposive sampling technique was used for sample collection.

In this study, a web-based pre-validated questionnaire (MAI) was used. MAI is a standardized tool developed

to assess individual metacognitive awareness.[15] It has 52 items divided into two main domains: Knowledge about cognition (declarative, procedural, and conditional) and regulation of cognition. (planning, information management strategies, comprehension monitoring, debugging strategies, and evaluation). Each item was rated as true and false with a 1 and 0 score. There were 17 questions related to knowledge about cognition, and 35 questions related to cognition regulation. The questionnaire was administered using Google Forms, and a brief electronic link was generated. This link was managed and sent over WhatsApp to private dental hospitals.

Demographic data included age, gender, designation (house officer, PG trainee, general dentist, or consultant), and years of clinical experience. All incomplete forms were excluded.

Ethical Approval

This study was conducted from April to June 2024 after approval by the Institutional Review Board of the University College of Dentistry, the University of Lahore, Pakistan (UCD/ERCA/24/237) on 26th March 2024.

Statistical Analysis

SPSS version 25 was used for data analysis. The frequency and percentage were calculated for categorical variables. Descriptive statistics such as the mean and standard deviation were calculated for continuous variables. Subgroup analyses were performed based on designation to identify group-specific trends. One-way ANOVA followed by post hoc analysis was performed to examine group differences. A p-value less than 0.05 was considered statistically significant.

RESULTS

There were 320 dental professionals, with the majority (59%) aged between 21 and 30. The study included 56% males and 44% females. Participants had varying experience levels; more than 50% had less than a year of experience. The study included 38% of HO, 30% of GD, 16% of PGR, and 15% of consultants. The MAI tool yielded a mean of total knowledge score=10.19±4.17, and a mean of total cognition score=21.45±7.96 with a maximum score of 35 (Table 1). Upon evaluating the metacognitive abilities of all participants using MAI, a substantial statistical distinction emerged, revealing that consultants exhibited higher total cognitive knowledge scores than HO. This pattern persisted across various subdomains of mental knowledge, including procedural knowledge, conditional knowledge, and declarative knowledge, all of which were statistically significant ($p<0.001$). GD showed the highest cognition score among all the others, with a statistically significant p-value as shown in Table 2.

In cognitive regulation, we observed disparities in total scores, reaffirming the consultants' consistently superior performance compared to other participants ($p<0.001$). When we examined specific subdomains within cognitive regulation, planning, and evaluation, substantial differences were observed, indicating the outperformance of consultants in contrast to HO and GD. Furthermore, significant statistical distinctions were evident in the subdomains of information management, communication, and debugging strategies. The data was statistically significant for both scores ($p<0.001$)

Examining the data through the lens of professional experience in Table 3, it becomes evident that individuals with over a decade of expertise demonstrated superior outcomes. In evaluating cognitive regulation, particularly in total scores, consultants consistently outperformed their peers, indicating a statistically significant difference ($p<0.001$).

Table 1: Metacognitive assessment scores

Metacognitive assessment domains	mean± SD
Knowledge about cognition	
Declarative Knowledge	4.58±2.07
Procedural Knowledge	2.12±1.52
Conditional Knowledge	3.50±1.40
Total Knowledge Score	10.1±4.17
Regulation of cognition	
Planning	4.52±1.87
Comprehension Monitoring	3.54±2.20
Information Management Strategies	6.59±2.46
Debugging Strategies	3.06±1.43
Evaluation	3.74±1.52
Total Cognition Score	21.45±7.9

This finding aligns with the concept that increased professional tenure may contribute to enhanced cognitive regulation skills. The observed excellence in total scores and specific subdomains among individuals with over a decade of experience underscores the potential positive influence of prolonged professional involvement on metacognitive

capabilities, particularly in planning and evaluation. It also implies that these seasoned professionals have cultivated more effective information management, communication, and debugging strategies, thereby contributing to their superior cognitive abilities.

Table 2: Comparison of metacognition levels among general dentists, house officers, postgraduate residents, and consultants.

Metacognitive assessment domains	House officers mean± SD	General dentists mean± SD	Postgraduate residents mean± SD	Consultants mean± SD
Knowledge about cognition				
Declarative Knowledge	3.80±1.49[b,d]	4.47±2.01[a,d]	4.02±1.77[d]	7.70±0.51[a,b,c]
Procedural Knowledge	1.79±1.36[d]	1.68±1.62[d]	2.23±1.26[d]	3.89±0.32[a,b,c]
Conditional Knowledge	2.94±1.46[b,d]	3.89±1.12[a,c,d]	2.98±1.21[b,d]	4.86±0.41[a,b,c]
Total Knowledge Score	8.53±3.29[b,d]	10.0±3.93[a,d]	9.23±3.28[b,d]	16.5±0.95[a,b,c]
Regulation of cognition				
Planning	3.57±1.80[b,d]	5.15±1.40[a,c,d]	3.98±1.58[d]	6.50±0.85[a,b,c]
Comprehension Monitoring	2.90±1.62[d]	3.29±2.47[d]	2.98±1.50[d]	6.57±0.90[a,b,c]
Information Management Strategies	5.54±2.26[b,d]	7.25±1.97[a,c,d]	5.46±2.21[b,d]	9.48±1.07[a,b,c]
Debugging Strategies	2.54±1.31[b,d]	3.09±1.32[a,d]	2.81±1.25[d]	4.77±0.71[a,b,c]
Evaluation	3.12±1.34[b,d]	3.91±1.41[a,d]	3.37±1.31[d]	5.64±0.75[a,b,c]
Total Cognition Score	17.7±6.12[b,d]	22.7±7.25[a,c,d]	18.6±5.95[b,d]	32.9±3.22[a,b,c]

A one-way ANOVA test followed by Tukey's post hoc test was applied. [a,b,c,d]Statistically significant difference ($p<0.05$). [a]compared to house officers, [b]compared to general dentists, [c]compared to postgraduate residents, [d]compared to the consultants

Table 3. Experience-wise comparison of metacognition level

Metacognitive assessment domains	<1 year Exp mean± SD	1-5 years Exp mean± SD	6-10 years Exp mean± SD	>10 years Exp mean± SD
Knowledge about cognition				
Declarative Knowledge	3.82±1.52[b,d]	4.72±2.14[a,c,d]	3.49±0.79[b,d]	7.78±0.42[a,b,c]
Procedural Knowledge	1.77±1.40[b,c,d]	2.49±1.39[a,c,d]	0.82±0.94[a,b,d]	3.88±0.33[a,b,c]
Conditional Knowledge	3.17±1.44[d]	3.22±1.39[d]	3.60±1.03[d]	4.8±0.53[a,b,c]
Total Knowledge Score	8.76±3.32[b,d]	10.43±4.21[a,c,d]	7.91±1.46[b,d]	16.46±0.97[a,b,c]
Regulation of cognition				
Planning	3.85±1.80[c,d]	4.45±1.82[d]	4.80±1.41[b,d]	6.48±0.89[a,b,c]
Comprehension Monitoring	2.91±1.73[b,c,d]	3.84±2.09[a,c,d]	1.84±1.26[a,b,d]	6.64±0.83[a,b,c]
Information Management Strategies	5.84±2.27[d]	6.37±2.62[d]	6.27±1.45[b,d]	9.52±1.03[a,b,c]
Debugging Strategies	2.68±1.32[d]	3.12±1.42[c,d]	2.38±0.83[b,d]	4.78±0.68[a,b,c]
Evaluation	3.26±1.42[b,d]	3.93±1.46[a,c,d]	3.13±0.73[b,d]	5.58±0.88[a,b,c]
Total Cognition Score	18.55±6.4[b,d]	21.7±8.15[a,d]	18.42±3.0[b,d]	33.1±3.35[a,b,c]

Exp = experience, One-way ANOVA and Tukey's post hoc test were applied. [a,b,c,d] Statistically significant difference $p<0.05$. [a] compared to <1 year Exp, [b] compared to 1-5 years Exp, [c] compared to 6-10 years Exp, [d] compared to <10 years Exp.

DISCUSSION

The present study determines the metacognition level among different dental healthcare professionals. According to the results of this study, consultants had the highest knowledge score, whereas general dentists scored highest on cognition. While these scores showed considerable variations among different levels of dental professionals, the trend was consistently high among consultants $p<0.001$.

Dental education is an amalgamation of learning and applying knowledge to the practical solution by judgmental reasoning, analysing multifactorial aspects of pathological processes, and making the final evidence-based reasoning of effective clinical decision-making.[16] Self-directed learning has gained massive importance in the current education models of healthcare as a way forward for making the current dental graduates lifelong learners.[17] The framework of self-directed learning approaches involves using one's cognitive abilities, metacognition, motivational variables, and the emotional components of it.[18] Metacognition is a process that reflects upon a learner's subconscious thinking, playing an important role in self-regulation, self-management, and critical

thinking toward learning.[19] Although metacognition plays a crucial role in the educational and learning strategies of dental professionals, there is limited research on the topic among this group. Even the rigorous research on the topic encompassing various platforms such as PubMed, Google Scholar, and Research Gate yielded very few studies on the topic of dental undergraduates. Emphasizing on metacognitive abilities in dental education and practices, the present study aimed to assess their level in different dental healthcare professionals.

The current study determined an increasing tendency of mean metacognitive knowledge scores from HO to GD and PG. The maximum mean metacognitive knowledge score was observed in consultants. There was a statistically significant difference in the mean knowledge score. This pattern reaffirmed the available literature where Hassan et al conducted research on metacognition among first to third-year dental students, the results showed a mean score of 39.07±6.68.[20] Another study on Paediatric fellows confirmed the limited presence of metacognitive skills among early-career physicians, with a mean score of RAR (2.4±1.3) having a range of scale as 0-6 and SMART-GR global IDP (2.8±1.0) with a range of score 1-5, as a metacognition assessment tool.[21]

The present study showed that when it comes to the practical application of metacognitive skills in self-regulation, there was a statistically significant difference in the mean results among GD when compared to the PG. The inference of the results showed that general dental practitioner can exercise their metacognitive abilities more effectively when compared to the PG students in the practical setting, where greater effort was required in terms of clinical reasoning and problem-solving abilities. However, the subdomain of metacognition regulation scores showed approximately comparable results for the evaluation strategies of GD, HO, and PG. The results were endorsed by another research that determined that no significant difference lies in the metacognitive evaluation practices among 1st year and fifth-year medical students who were close to starting their independent clinical journey thus concluded that experiencing a similar education model does not make a significant difference for the use of higher order metacognitive abilities for self-evaluation.[22] The difference in results might be due to using different curricular models in the comparative studies.[3]The research done on clinical PG students of India revealed MAI scores for cognitive regulation as (19.9±3.8), which were comparable to the score determined in the present study.[23] Metacognitive skills improve clinical reasoning, critical thinking, and problem-solving approaches. As evident from the findings of the present research, consultants outperform in the presence of metacognitive knowledge and metacognitive regulation scores compared to other groups. Furthermore, the observation corroborates the correlation between experience and metacognition scores. In the current study, dental professionals with >10 years of experience reported the highest MAI score. The previous study conducted on clinicians having experience in the range of 7-32 years concluded that there was an improvement in their metacognitive skills over time after teaching the metacognitive strategies to prospective medical graduates. This, in return, reflects in their better self-regulation and clinical decision-making.[24]

Consultants, particularly those with higher experience (over a decade), exhibited significantly superior scores in all metacognitive domains. This highlights the positive impact of clinical experiences on cognitive regulation and knowledge. These findings reinforce the importance of sustained professional development in cultivating deeper metacognitive awareness among professionals.

Considering the study findings, it is recommended that dental education programs incorporate structured training on metacognitive strategies. This can help enhance self-regulated learning, critical thinking, and clinical decision-making among dental professionals. Workshops and continuous professional development sessions focused on improving metacognitive awareness can be beneficial, particularly for early-career practitioners.

CONCLUSION

The metacognition level of consultants and general dentists was highest among dental professionals. This study highlights the need to inculcate self-learning using their metacognitive abilities in dental professionals so that learning would become more focused and improvement in skills would take place.

Limitations of study and future recommendations:

The present study determined the metacognitive assessment scores of the dentists through the self-assessment MAI tool, which may reflect the self-reporting bias through overestimation of one's ability. Future research should investigate the long-term

impact of metacognitive training on academic outcomes and clinical performance. Additionally, expanding studies to include public sector institutions and interdisciplinary healthcare teams may offer a more comprehensive understanding of metacognitive development in diverse educational settings.

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- **KJ:** Study design, data acquisition & analysis, manuscript drafting
- **TN**: Conception of study, data acquisition & analysis, manuscript drafting, critical review
- **AC:** Data collection, critical review, manuscript drafting
- **AI:** Conception of study, study design, interpretation of data, critical review
- **TS:** Data collection, critical review, manuscript drafting
- **MAA:** Data collection and manuscript drafting

All authors approved the final version to be published and agreed to be accountable for all aspects of the work, ensuring that any questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

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