



Original Research Article

Barriers and Facilitators to the Use of Adhesive Dentistry in Routine Clinical Practice: A Mixed-Methods Study from Karachi, Pakistan

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Abstract: **Background:** Adhesive dentistry represents a cornerstone of contemporary restorative dental practice, offering minimally invasive solutions that preserve tooth structure and improve long-term clinical outcomes. Despite its well-established evidence base, the routine integration of adhesive techniques into everyday clinical practice remains inconsistent, particularly within resource-constrained healthcare settings. In Karachi, Pakistan's largest urban Centre, little empirical evidence existed regarding the factors that impede or facilitate the adoption of adhesive dentistry among practicing clinicians. **Objectives:** This study aimed to identify and categorize the barriers and facilitators influencing the use of adhesive dentistry in routine clinical practice in Karachi, to explore their relationship with clinicians' demographic and professional characteristics, and to generate contextually grounded recommendations for practice improvement. **Methods:** A sequential explanatory mixed-methods design was employed. In the quantitative phase, a validated structured questionnaire was administered to 312 dental practitioners recruited through stratified purposive sampling across public, private, and academic dental settings in Karachi. Data were analyzed using descriptive statistics, independent samples t-tests, one-way ANOVA, binary logistic regression, and exploratory factor analysis. In the qualitative phase, 22 semi-structured in-depth interviews were conducted with a purposively selected subset of participants and analyzed using reflexive thematic analysis. **Results:** A response rate of 78.0% was achieved. The most frequently reported barriers were the high cost of adhesive materials (86.9%), limited access to continuing professional development (81.4%), technique sensitivity of adhesive procedures (76.3%), and inadequate undergraduate training (73.4%). A contextually specific barrier load shedding and its impact on light-curing reliability was endorsed by 62.2% of participants, a finding not previously reported in the adhesive dentistry literature. Hands-on training workshops (92.6%), availability of affordable materials (85.6%), and clinical guidelines from professional bodies (77.2%) were the most valued facilitators. Specialist practitioners and those affiliated with teaching institutions demonstrated significantly higher knowledge and confidence scores compared to general dental practitioners in standalone private practice. Qualitative findings corroborated and enriched the quantitative results, generating four overarching themes: economic realities and material constraints, educational gaps and training inadequacies, contextual and infrastructure challenges, and enablers of practice change. **Conclusion:** The integration of adhesive dentistry into routine clinical practice in Karachi was constrained by a convergent set of economic, educational, and infrastructural barriers, several of which are specific to the low- and middle-income country context. Targeted interventions encompassing curricular reform, accessible and accredited continuing professional development, digital peer learning, advocacy for reduced material costs, and the development of locally adapted clinical guidelines are essential to bridge the evidence-to-practice gap in adhesive dentistry within the Pakistani healthcare setting.

Keywords: adhesive dentistry, barriers, facilitators, clinical practice, Karachi, Pakistan, mixed methods, dental education, continuing professional development.

INTRODUCTION

Adhesive dentistry has fundamentally transformed the landscape of restorative dental practice over the past six decades, evolving from Buonocore's pioneering description of acid-etching in 1955 to the sophisticated multi-step and self-adhesive bonding

systems available to clinicians today (Van Meerbeek et al., 2020). At its core, adhesive dentistry encompasses a range of techniques and materials that enable the bonding of restorative substrates including composite resins, ceramics, and resin cements to enamel and dentine, facilitating minimally invasive

approaches that conserve tooth structure and deliver aesthetically superior outcomes (Peumans et al., 2005). The clinical advantages of adhesive restorative approaches over conventional, mechanically retentive techniques are well established in the literature, encompassing improved marginal integrity, reduced microleakage, enhanced pulpal protection, and greater conservation of sound tooth tissue (Vanherle et al., 2022). As the global dental profession has progressively embraced the philosophy of minimally invasive dentistry, adhesive techniques have come to occupy a central role in the management of carious lesions, tooth wear, aesthetic rehabilitation, and indirect restorative workflows (Frencken et al., 2012).

Despite this robust evidence base, a persistent and well-documented gap exists between the theoretical endorsement of adhesive dentistry and its consistent application in routine clinical practice. Studies conducted across diverse international settings have demonstrated that a significant proportion of dental practitioners continue to rely upon older, more conventional restorative approaches, citing a range of material, educational, economic, and systemic factors as impediments to the adoption of contemporary adhesive techniques (Uribe et al., 2014; Schwendicke et al., 2015). This evidence-to-practice gap is not unique to adhesive dentistry; it reflects a broader challenge within health professions practice, wherein the translation of research evidence into routine clinical behaviour is frequently delayed, incomplete, or unevenly distributed across professional groups and healthcare settings (Grol & Grimshaw, 2003). Understanding the specific barriers and facilitators that shape clinical behaviour change is therefore a prerequisite for the design of effective interventions aimed at improving the quality and consistency of adhesive restorative care.

In the context of Pakistan, and specifically Karachi the country's largest metropolitan city with a population exceeding 16 million the delivery of dental care is characterized by significant structural complexity. The city's dental workforce operates across a highly heterogeneous landscape of public sector teaching hospitals, private specialist clinics, and community-based general dental practices, serving a patient population that spans the full spectrum of socio-economic diversity (Nishtar et al., 2013). The public health infrastructure in Karachi, as in much of urban Pakistan, is subject to well-documented resource constraints, including inconsistent material

procurement, limited access to continuing professional education, and persistent infrastructural challenges such as unreliable electricity supply factors that may uniquely shape the barriers experienced by dental practitioners in this setting (Zaidi et al., 2019). Furthermore, the dental education system in Pakistan, governed by the PMDC, has been subject to critique regarding the adequacy of clinical training in contemporary restorative techniques at the undergraduate level, raising concerns about the preparedness of newly qualified graduates for evidence-based adhesive practice (Baig & Mehtar, 2013).

Notwithstanding these contextual realities, empirical research examining the barriers and facilitators to adhesive dentistry adoption within the Pakistani dental context remains conspicuously absent from the literature. The existing body of evidence on this topic has been generated predominantly in high-income countries, where the material, educational, and infrastructural determinants of clinical practice differ substantially from those encountered by practitioners in low- and middle-income country settings such as Karachi (Peumans et al., 2005; Uribe et al., 2014). This represents a significant gap in the global evidence base, as interventions and recommendations derived from high-income contexts may hold limited relevance or transferability to the realities of dental practice in Pakistan.

It is against this backdrop that the present study was undertaken. By employing a sequential explanatory mixed-methods design, this study sought to generate a comprehensive and contextually grounded understanding of the barriers and facilitators influencing the use of adhesive dentistry in routine clinical practice among dental practitioners in Karachi. Quantitative survey data provided breadth of coverage across a large and professionally diverse sample, while qualitative in-depth interviews offered depth of insight into the lived experiences, perceptions, and professional behaviours of clinicians navigating the demands of adhesive practice within a resource-constrained urban environment. The findings of this study are intended to inform targeted, feasible, and contextually appropriate interventions at the level of dental education, professional development, institutional policy, and health system governance in Pakistan.

routine clinical practice in Karachi, Pakistan. Mixed-methods approaches are particularly suited to health professions research where complex behavioural and attitudinal phenomena require both breadth and depth of inquiry (Creswell & Plano Clark, 2018). The sequential explanatory design prioritized quantitative

METHODOLOGY

Study Design

This study employed a sequential explanatory mixed-methods design, integrating quantitative survey data with qualitative in-depth interviews to provide a comprehensive understanding of the barriers and facilitators influencing the use of adhesive dentistry in

data in the first phase, which was subsequently elaborated and contextualized through qualitative exploration in the second phase (Fetters, Curry & Creswell, 2013). Given the heterogeneous nature of dental practice in Karachi spanning under-resourced public sector institutions, private clinics, and tertiary academic hospitals, this design was deemed particularly appropriate for capturing the multifaceted realities of clinical practice in a large, resource-constrained urban setting (Zaidi et al., 2019).

Study Population and Sampling

The target population comprised qualified dental practitioners currently engaged in clinical practice in Karachi, including general dental practitioners, restorative dentists, and specialist prosthodontists registered with the Pakistan Medical and Dental Council (PMDC). Karachi, as the largest metropolitan city in Pakistan and home to several major dental teaching institutions including Aga Khan University Hospital, Dow University of Health Sciences, and Karachi Medical and Dental College provided a sufficiently diverse and representative setting for the study (Nishtar et al., 2013). A stratified purposive sampling strategy was employed to ensure representation across practice settings (primary care, secondary/tertiary care, and private practice), years of clinical experience, and professional qualification levels.

For the quantitative phase, a minimum sample size of 300 participants was targeted, calculated using established power analysis conventions for survey-based research (Kelley & Preacher, 2012). For the qualitative phase, a purposive sample of 20–25 participants were recruited until data saturation was achieved (Guest, Bunce & Johnson, 2006). Inclusion criteria required participants to hold a recognised dental qualification (BDS or above), to be actively practising in Karachi at the time of the study, and to have a minimum of one year of post-qualification clinical experience. Practitioners who had been absent from active clinical practice for more than six consecutive months were excluded.

Data Collection

Phase I: Quantitative Survey: A structured, self-administered questionnaire was developed based on a systematic review of existing literature on adhesive dentistry and barriers to evidence-based clinical practice (Uribe et al., 2014; Van Meerbeek et al., 2020). The instrument was piloted with a subset of 30 clinicians affiliated with dental institutions in Karachi prior to full deployment, to assess clarity, face validity, and internal consistency (Tavakol & Dennick, 2011). Revisions were made in response to pilot feedback, particularly regarding the contextual appropriateness of certain material-related and cost-related items within the Pakistani healthcare setting.

The final questionnaire encompassed five domains: (i)

demographic and professional background; (ii) awareness and knowledge of adhesive dentistry systems; (iii) perceived clinical barriers, including cost of materials, limited access to continuing dental education, and inadequate institutional support; (iv) perceived facilitators and enablers; and (v) attitudes toward professional development in adhesive dentistry. Responses were measured on a validated five-point Likert scale. The survey was disseminated both electronically via WhatsApp-based professional dental networks a primary mode of professional communication among clinicians in Pakistan (Hameed et al., 2020) and in person at selected dental institutions and clinics across Karachi's major districts, including Saddar, Gulshan-e-Iqbal, North Nazimabad, and Clifton. Two follow-up reminders were issued to maximise response rates (Edwards et al., 2009).

Phase II – Qualitative Interviews: Semi-structured, in-depth interviews were conducted with a purposively selected subset of survey respondents representing diverse professional profiles, practice settings, and years of experience. Interview guides were developed iteratively and informed by findings from Phase I, ensuring thematic coherence between the two phases (Morse & Niehaus, 2009). Interviews were conducted in English or Urdu, according to the preference of the participant, and were audio-recorded with informed written consent. All Urdu-language interviews were professionally transcribed and translated into English, with back-translation conducted on a random 20% subsample to ensure accuracy (Squires, 2009). Data collection continued until theoretical saturation was reached, as indicated by the absence of new emergent themes across successive interviews (Braun & Clarke, 2006).

Data Analysis

Quantitative data were analyzed using IBM SPSS Statistics (version 28.0). Descriptive statistics were used to summarize demographic variables and response distributions. Inferential analyses including independent samples t-tests, one-way analysis of variance (ANOVA), and binary logistic regression were conducted to examine associations between demographic variables and attitudinal outcomes, with statistical significance set at $p < 0.05$ (Field, 2018). Exploratory factor analysis was employed to identify latent constructs underlying the perceived barrier and facilitator items (Costello & Osborne, 2005).

Qualitative data were subjected to reflexive thematic analysis following the framework proposed by Braun and Clarke (2006, 2019), encompassing the iterative phases of familiarization, coding, theme generation, review, definition, and reporting. NVivo (version 14) software was utilized to facilitate systematic data management and coding. An audit trail was maintained throughout the analytical process to ensure transparency and trustworthiness (Lincoln &

Guba, 1985). Member checking was conducted by sharing emergent themes with a representative sample of participants, and peer debriefing sessions were held with two independent qualitative researchers to enhance the credibility of interpretation.

Integration of findings from both phases was undertaken during the interpretation stage, wherein quantitative results were elaborated and contextualised by qualitative insights, enabling a nuanced and theoretically grounded account of barriers and facilitators within the specific socio-economic and healthcare infrastructure context of

Karachi (Fetters et al., 2013).

Ethical Considerations

Participation was entirely voluntary, and all participants provided written informed consent before enrolment. Anonymity and data confidentiality were rigorously maintained throughout; all data were stored on password-protected institutional servers and handled in accordance with applicable institutional and national data protection guidelines. Participants retained the right to withdraw at any stage without consequence or prejudice to their professional standin

RESULTS

Participant Demographics

A total of 312 dental practitioners participated in the quantitative phase of the study, yielding a response rate of 78.0%. The majority of respondents were female ($n = 187$, 59.9%), reflecting the increasingly feminized composition of the dental workforce in Karachi (Table 1). The largest professional cohort comprised general dental practitioners ($n = 143$, 45.8%), followed by postgraduate trainees ($n = 89$, 28.5%), and specialists in restorative dentistry or prosthodontics ($n = 80$, 25.6%). In terms of practice setting, 134 participants (42.9%) were employed in private practice exclusively, 98 (31.4%) worked within public sector or teaching institutions, and 80 (25.6%) reported dual employment across both sectors. The mean duration of clinical experience was 8.4 years ($SD = 5.2$), ranging from one to 31 years. For the qualitative phase, 22 participants were interviewed, and data saturation was confirmed after the 19th interview.

Table 1 Demographic Characteristics of Study Participants (N = 312)

Variable	Category	n	%
Gender	Male	125	40.1
	Female	187	59.9
Qualification	BDS	143	45.8
	FCPS/MDS Trainee	89	28.5
	Specialist (FCPS/MDS)	80	25.6
Practice Setting	Private only	134	42.9
	Public/Teaching	98	31.4
	Dual (Public + Private)	80	25.6
Experience	1–5 years	108	34.6
	6–10 years	97	31.1
	11–20 years	74	23.7
	>20 years	33	10.6

Awareness and Knowledge of Adhesive Dentistry

Overall awareness of adhesive dentistry systems was moderate to high among participants. A large majority ($n = 276$, 88.5%) reported familiarity with the concept of adhesive dentistry, yet only 171 (54.8%) indicated confidence in selecting an appropriate adhesive system for a given clinical scenario. Awareness was significantly higher among specialists compared to general dental practitioners ($M = 4.21$ vs. $M = 3.14$; $t(310) = 9.84$, $p < 0.001$, $d = 0.78$), indicating a meaningful gap in applied knowledge across professional strata. Postgraduate trainees affiliated with teaching hospitals in Karachi including Dow University of Health Sciences and Karachi Medical and Dental College demonstrated notably higher scores on knowledge items than their peers in standalone private practice ($M = 4.07$ vs. $M = 3.09$; $p < 0.001$).

Perceived Barriers to the Use of Adhesive Dentistry

Exploratory factor analysis of the 22-item barrier subscale yielded a four-factor solution, accounting for 61.3% of the total variance ($KMO = 0.84$; Bartlett's test of sphericity: $\chi^2(231) = 2847.6$, $p < 0.001$). The four identified factors were labelled: (1) Material Cost and Accessibility, (2) Knowledge and Training Deficits, (3) Time and Technique Sensitivity, and (4) Institutional and Systemic Constraints (Table 2).

Table 2 Factor Loadings for Perceived Barriers Subscale (N = 312)

Item	Factor 1: Cost & Access	Factor 2: Knowledge & Training	Factor 3: Time & Technique	Factor 4: Institutional I
High cost of adhesive materials	0.81	—	—	—
Unavailability of quality materials locally	0.78	—	—	—
Reliance on imported products	0.74	—	—	—
Lack of formal training in adhesive systems	—	0.80	—	—
Insufficient undergraduate curriculum coverage	—	0.77	—	—
Limited access to CPD opportunities	—	0.72	—	—
Moisture sensitivity of adhesive procedures	—	—	0.79	—
Time-consuming bonding protocols	—	—	0.76	—
Technique sensitivity in clinical application	—	—	0.73	—
Lack of institutional procurement support	—	—	—	0.82
Absence of standardised protocols in workplace	—	—	—	0.75
Load shedding/power interruptions affecting curing	—	—	—	0.69

Note. Only loadings ≥ 0.40 are reported. CPD = Continuing Professional Development.

The most frequently endorsed barrier was the high cost of adhesive materials ($n = 271$, 86.9%), followed by limited access to continuing professional development (CPD) opportunities ($n = 254$, 81.4%), and the technique sensitivity of adhesive procedures ($n = 238$, 76.3%). Notably, 194 participants (62.2%) identified load shedding and power supply interruptions — a persistent infrastructural challenge in Karachi — as a contextually specific barrier affecting the reliable use of light-curing units. Binary logistic regression indicated that practice setting was a significant predictor of reporting cost as a primary barrier (OR = 2.47, 95% CI [1.63, 3.74], $p < 0.001$), with practitioners in public sector institutions significantly more likely to cite material cost and procurement limitations than those in private practice.

Table 3 Frequency and Ranking of Perceived Barriers (N = 312)

Barrier	n	%	Mean (SD)
High cost of adhesive materials	271	86.9	4.41 (0.71)
Limited CPD opportunities in Karachi	254	81.4	4.28 (0.83)
Technique sensitivity of procedures	238	76.3	4.11 (0.91)
Inadequate undergraduate training	229	73.4	4.03 (0.88)
Unavailability of preferred materials locally	218	69.9	3.94 (0.97)
Time constraints in busy clinical settings	201	64.4	3.87 (1.02)
Power supply interruptions (load shedding)	194	62.2	3.76 (1.09)
Lack of institutional protocol guidance	183	58.7	3.61 (1.04)
Patient financial constraints	176	56.4	3.54 (1.11)
Absence of peer mentorship	149	47.8	3.29 (1.18)

Note. Responses measured on a five-point Likert scale (1 = Strongly Disagree; 5 = Strongly Agree).

Perceived Facilitators to the Use of Adhesive Dentistry

Exploratory factor analysis of the facilitator subscale yielded a three-factor solution, explaining 57.8% of total variance (KMO = 0.81; Bartlett's test: $\chi^2(190) = 2341.3$, $p < 0.001$). The three factors were identified as: (1) Education and Professional Development, (2) Material Accessibility and Affordability, and (3) Institutional and Peer Support. The most strongly endorsed facilitator was the availability of structured hands-on training workshops ($n = 289$, 92.6%), followed by the availability of locally manufactured or more affordable adhesive materials ($n = 267$, 85.6%), and access to clinical guidelines endorsed by professional bodies such as the Pakistan Dental Association ($n = 241$, 77.2%). One-way ANOVA revealed a statistically significant difference in facilitator scores across experience groups ($F(3, 308) = 7.43$, $p < 0.001$), with post-hoc Tukey analysis indicating that practitioners with more than 10 years of experience rated institutional mentorship significantly higher as a facilitator compared to those with fewer than five years ($p = 0.003$).

Table 4 Frequency and Ranking of Perceived Facilitators (N = 312)

Facilitator	n	%	Mean (SD)
Hands-on training workshops and courses	289	92.6	4.63 (0.58)
Availability of affordable local materials	267	85.6	4.39 (0.74)
Clinical guidelines from professional bodies	241	77.2	4.17 (0.86)
Integration of adhesive dentistry in postgraduate curricula	233	74.7	4.09 (0.91)
Mentorship from senior/specialist colleagues	224	71.8	3.98 (0.94)
Dedicated chair time within clinical schedules	198	63.5	3.81 (1.01)
Institutional procurement of quality materials	187	59.9	3.68 (1.07)
Peer discussion and case-based learning	179	57.4	3.57 (1.09)

Qualitative Findings

Reflexive thematic analysis of the 22 interview transcripts generated four overarching themes: (1) Economic Realities and Material Constraints, (2) Educational Gaps and Training Inadequacies, (3) Contextual and Infrastructure Challenges, and (4) Enablers of Practice Change. Representative participant quotations are presented to substantiate each theme.

Theme 1: Economic Realities and Material Constraints. Participants consistently described the prohibitive cost of internationally branded adhesive systems as a fundamental impediment to their routine use. One specialist prosthodontist practicing in a private clinic in Clifton remarked.

"The materials we were trained on during our FCPS universal adhesives, the self-etch systems they are simply not affordable for the average patient in Karachi. I find myself reverting to older, cheaper systems just to make the treatment viable."

This theme closely aligned with the quantitative finding that 86.9% of respondents identified material cost as the leading barrier and was particularly pronounced among practitioners serving lower-income patient populations in districts such as Lyari and Orangi Town.

Theme 2: Educational Gaps and Training Inadequacies. A recurring concern among general dental practitioners was the perceived insufficiency of adhesive dentistry training at the undergraduate level. Participants described curricula that were heavily weighted toward theoretical knowledge, with limited supervised clinical application of contemporary adhesive techniques. A newly qualified BDS graduate reflected

"In five years of dental school, I remember perhaps two or three sessions on bonding agents. When I got into practice, I honestly was not confident choosing between a two-step and a three-step system."

Theme 3: Contextual and Infrastructure Challenges. Several participants drew attention to challenges unique to the Karachi context, most notably the impact of intermittent electricity supply on the reliability of light-curing procedures. A general practitioner operating in North Nazimabad noted.

"Load shedding is a real clinical problem. If the power goes in the middle of a bonding procedure, the whole thing is compromised. I have started keeping a battery-operated curing light, but not everyone can afford that."

Theme 4: Enablers of Practice Change. Participants identified peer learning networks, particularly informal WhatsApp groups among dental practitioners, as an accessible and valued source of continuing education within the Karachi context. Specialist-led hands-on workshops, when accessible, were consistently described as transformative for clinical confidence.

DISCUSSION

This study provided a comprehensive, mixed-methods account of the barriers and facilitators influencing the integration of adhesive dentistry into routine clinical

practice among dental practitioners in Karachi. The findings revealed that while awareness of adhesive dentistry was broadly high, practical application remained constrained by a convergent set of economic, educational, infrastructural, and

institutional factors. These results both corroborate and extend the existing international literature, while illuminating contextually specific challenges that are largely absent from studies conducted in high-income settings. The identification of material cost as the most prevalent barrier (86.9%) was consistent with findings reported in comparable studies conducted in developing and lower-middle-income country contexts (Uribe et al., 2014; Schwendicke et al., 2015). However, the magnitude of this barrier in the Karachi setting appeared considerably more acute than that reported in European or North American studies, where cost featured less prominently as a primary impediment (Peumans et al., 2005). This disparity is attributable in part to Pakistan's heavy reliance on imported dental materials, which are subject to import duties and currency fluctuation, rendering internationally branded adhesive systems financially inaccessible for a significant proportion of both practitioners and patients (Nishtar et al., 2013). The qualitative data further illuminated the downstream consequences of this barrier, with practitioners describing a pragmatic reversion to older, less evidence-based adhesive protocols in order to maintain patient affordability a finding with significant implications for clinical quality and long-term restoration longevity (Van Meerbeek et al., 2020). The finding that fewer than 55% of participants expressed confidence in selecting an appropriate adhesive system for clinical use underscores a substantial gap between theoretical awareness and applied competency. This is consistent with the broader literature on evidence-to-practice translation in dentistry, wherein knowledge acquisition alone has been demonstrated to be insufficient for behaviour change in the absence of structured clinical skill development (Grol & Grimshaw, 2003). The qualitative data enriched this finding considerably, revealing that undergraduate dental education in Karachi institutions inadequately prepared graduates for the demands of contemporary adhesive practice. This mirror concerns raised in the Pakistani dental education literature more broadly, where curricula have been critiqued for their disproportionate emphasis on didactic instruction over competency-based clinical training (Baig & Mehtar, 2013). The significantly higher knowledge and confidence scores observed among postgraduate trainees affiliated with teaching hospitals suggest that supervised clinical exposure within structured postgraduate programmes may partially compensate for undergraduate deficiencies, though access to such programmes remains unequally distributed across the city. A particularly salient finding of this study was the identification of load shedding intermittent electricity supply as a clinically significant barrier to adhesive dentistry, endorsed by 62.2% of participants. To the authors' knowledge, this contextually specific barrier has not been previously reported in the adhesive

dentistry literature, which has been largely produced within infrastructure-stable settings. The reliance of contemporary adhesive protocols on light-curing technology renders this a non-trivial clinical concern; inadequate or interrupted polymerization has well-documented consequences for the mechanical properties and longevity of adhesive restorations (Rueggeberg, 2011). This finding has direct implications for the design of clinical protocols and material procurement policies in Karachi and comparable urban settings in low- and middle-income countries (LMICs), where battery-operated or solar-powered curing devices may represent a pragmatic and evidence-aligned solution. The near-universal endorsement of hands-on training workshops as the most valued facilitator (92.6%) carries significant implications for continuing professional development policy in Karachi. This finding is consistent with the broader health professions education literature, which has consistently demonstrated the superiority of experiential, skills-based learning over didactic instruction in promoting durable behaviour change among practicing clinicians (Forsetlund et al., 2009). The prominence of informal peer networks, particularly WhatsApp-based professional communities as an accessible CPD resource within the Karachi context is a novel finding that reflects the broader global phenomenon of social media-facilitated professional learning (Hameed et al., 2020). Professional bodies, including the Pakistan Dental Association and the College of Physicians and Surgeons Pakistan, may leverage these existing digital networks as cost-effective platforms for disseminating clinical guidelines, case-based discussions, and evidence summaries related to adhesive dentistry. The finding that institutional mentorship was rated significantly more highly as a facilitator by experienced practitioners (>10 years) relative to early-career clinicians is noteworthy. It is plausible that senior practitioners, having witnessed the evolution of adhesive materials and techniques over time, possessed a more refined appreciation of the role that mentorship played in their own professional development. Conversely, newly qualified practitioners may have been less aware of the value of structured mentorship, having limited exposure to formalized mentoring relationships during their training. This has implications for the design of induction and early-career support programmes within dental institutions across Karachi.

Limitations

Several limitations of this study warrant acknowledgement. First, the cross-sectional survey design precluded causal inference regarding the relationships between demographic variables and attitudinal outcomes. Second, the reliance on self-reported data introduced the possibility of social desirability bias, whereby participants may have overestimated their knowledge or underreported their

use of outdated techniques. Third, while every effort was made to achieve representativeness through stratified sampling, the study was confined to Karachi, and its findings may not be directly generalizable to other Pakistani cities or rural dental practice contexts. Finally, the exclusion of dental auxiliary staff and dental technicians, who play a meaningful role in the adhesive workflow, represents a boundary of the current inquiry that future research may productively address.

CONCLUSION

This study offered a nuanced, contextually grounded account of the barriers and facilitators shaping adhesive dentistry practice in Karachi. Material cost, educational deficits, and infrastructural challenges particularly the impact of load shedding on light-curing reliability emerged as the most significant impediments to integration. Conversely, hands-on training, the availability of affordable materials, and peer-based professional networks constituted the most valued enablers. These findings collectively point toward a multi-level intervention strategy encompassing curriculum reform, targeted CPD investment, institutional procurement support, and the harnessing of digital professional communities to bridge the evidence-to-practice gap in adhesive dentistry within the Pakistani healthcare context.

Recommendations

Undergraduate dental training should place greater emphasis on supervised clinical practice in adhesive dentistry to ensure basic competency among graduates.

Professional bodies should provide affordable, hands-on CPD programs focused on practical skills and ensure wider access across different areas of Karachi. Digital platforms can be used for peer learning through case discussions and knowledge sharing to support continuous professional development.

Policy efforts are needed to reduce the cost of adhesive materials through duty reductions and bulk procurement systems, while promoting cost-effective alternatives in clinical practice.

Infrastructural issues such as power outages should be addressed by encouraging the use of rechargeable curing units and appropriate adhesive systems suitable for local conditions.

Mentorship programs should be strengthened in clinical settings to support early-career practitioners in improving confidence and skills.

Locally relevant clinical guidelines should be developed, and future research should be expanded to other cities and include patient perspectives.

REFERENCES

1. Baig, L., & Mehtar, S. (2013). Undergraduate

medical education in Pakistan: A review. *Journal of the Pakistan Medical Association*, 63(7), 947–953.

2. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101.
3. Braun, V., & Clarke, V. (2019). Reflecting on reflexive thematic analysis. *Qualitative Research in Sport, Exercise and Health*, 11(4), 589–597.
4. Costello, A. B., & Osborne, J. W. (2005). Best practices in exploratory factor analysis. *Practical Assessment, Research & Evaluation*, 10(7), 1–9.
5. Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE Publications.
6. Edwards, P. J., Roberts, I., Clarke, M. J., DiGuseppi, C., Wentz, R., Kwan, I., Cooper, R., Felix, L. M., & Pratap, S. (2009). Methods to increase response to postal and electronic questionnaires. *Cochrane Database of Systematic Reviews*, (3), MR000008.
7. Fetters, M. D., Curry, L. A., & Creswell, J. W. (2013). Achieving integration in mixed methods designs. *Health Services Research*, 48(6pt2), 2134–2156.
8. Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5th ed.). SAGE Publications.
9. Forsetlund, L., Bjørndal, A., Rashidian, A., Jamtvedt, G., O'Brien, M. A., Wolf, F., & Oxman, A. D. (2009). Continuing education meetings and workshops. *Cochrane Database of Systematic Reviews*, (2), CD003030.
10. Frencken, J. E., Sharma, P., Stenhouse, L., Green, D., Laverty, D., & Dietrich, T. (2012). Contemporary use of glass ionomer cement materials. *Dental Materials*, 28(1), 83–92.
11. Grol, R., & Grimshaw, J. (2003). From best evidence to best practice. *The Lancet*, 362(9391), 1225–1230.
12. Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? *Field Methods*, 18(1), 59–82.
13. Hameed, A., Fatima, G. R., Malik, S., Ishtiaq, S., & Malik, M. (2020). Use of social media among healthcare professionals in Pakistan. *Journal of Ayub Medical College*, 32(1), 110–114.
14. Kelley, K., & Preacher, K. J. (2012). On effect size. *Psychological Methods*, 17(2), 137–152.
15. Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. SAGE Publications.
16. Morse, J. M., & Niehaus, L. (2009). *Mixed method design*. Left Coast Press.
17. Nishtar, S., Boerma, T., Amjad, S., Alam, A. Y., Khalid, F., ul Haq, I., & Mirza, Y. A. (2013). Pakistan's health system. *The Lancet*, 381(9884), 2193–2206.
18. Peumans, M., Kanumilli, P., De Munck, J., Van Landuyt, K., Lambrechts, P., & Van Meerbeek, B. (2005). Clinical effectiveness of contemporary

- adhesives. *Dental Materials*, 21(9), 864–881.
19. Rueggeberg, F. A. (2011). State-of-the-art: Dental photocuring. *Dental Materials*, 27(1), 39–52.
20. Schwendicke, F., Frencken, J. E., Bjørndal, L., Maltz, M., Manton, D. J., Ricketts, D., & Innes, N. (2015). Managing carious lesions. *Journal of Dental Research*, 95(7), 791–799.
21. Squires, A. (2009). Methodological challenges in cross-language qualitative research. *International Journal of Nursing Studies*, 46(2), 277–287.
22. Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education*, 2, 53–55.
23. Uribe, S. E., Innes, N., & Mela, M. (2014). Barriers to evidence-based dentistry. *Journal of Evidence-Based Dental Practice*, 14(3), 132–139.
24. Van Meerbeek, B., Yoshihara, K., Van Landuyt, K., Yoshida, Y., & Peumans, M. (2020). From Buonocore's pioneering acid-etch technique to self-adhering materials. *Dental Materials*, 36(1), 6–36.
25. Vanherle, G., Mjör, I. A., & Van Meerbeek, B. (2022). Guidelines for adhesive dentistry in clinical practice. *European Federation of Conservative Dentistry*.
26. Zaidi, S. M. A., Bigdeli, M., Langlois, E. V., & Ter Veen, A. (2019). Health systems challenges in Pakistan. *BMJ Global Health*, 4(Suppl 6), e001619.