JHWCR JOURNAL OF HEALTH, WELLNESS AND COMMUNITY RESEARCH 3007-0570

Original Article Volume 4, Issue 2

# From Fluoride to Flavours: Dental Undergraduates and Dentists' Perspectives on Non Therapeutic Additives in Pediatric Toothpaste in Pakistan

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## ABSTRACT

***Background:*** *Pediatric toothpastes commonly combine therapeutic fluoride with non-therapeutic additives (flavors, sweeteners, colors, preservatives, surfactants) to improve child acceptability; however, inappropriate fluoride use and uncertainty about additive safety may influence professional recommendations and parental counseling.* ***Objective:*** *To assess knowledge, perceptions, and self-reported practices regarding fluoride use, fluoride-free alternatives, and non-therapeutic additives in pediatric toothpaste among dental undergraduates and dentists in Pakistan.* ***Methods:*** *A cross-sectional observational survey was conducted from September 2025 to January 2026 using a structured, content-validated online questionnaire distributed via academic/professional networks. Clinical-year undergraduates, house officers, general dentists, and postgraduates/specialists were eligible. Descriptive statistics were reported, and group comparisons between undergraduates and qualified dentists were evaluated using chi-square tests (α=0.05) in IBM SPSS Statistics v26.* ***Results:*** *Of 302 responses, 294 were analyzed; 67.9% were undergraduates and 76.2% were female. Awareness of recommended pediatric fluoride concentration was 77.5% overall and higher among dentists than undergraduates (86.3% vs 73.0; p=0.011). Agreement that fluoride prevents caries (91.7%) and concern about fluorosis with overuse (89.1%) were high and similar between groups. Dentists more often recommended the guideline-preferred smear/rice-grain amount for children <3 years (54.7% vs 42.0; p=0.005). Nearly all participants endorsed flavors as important for compliance (99.7%) and supported stricter regulation of fluoride/additives (95.0%).* ***Conclusion:*** *Pakistani dental professionals strongly endorse fluoride efficacy but show clinically relevant gaps in guideline-concordant dosing and variable fluoride knowledge, supporting targeted education and clearer regulation of pediatric toothpaste formulations*

***Keywords:*** *pediatric toothpaste; fluoride; dental fluorosis; non-therapeutic additives; flavors; dental students; Pakistan; cross-sectional survey*

## INTRODUCTION

Dental caries is a chronic, biofilm-mediated and largely preventable disease that remains one of the most prevalent oral health problems worldwide, particularly among children. The disease process is driven by a sustained imbalance between demineralization and remineralization at the tooth surface, initiated by the metabolism of fermentable carbohydrates by cariogenic bacteria within dental biofilms (1). Despite advances in preventive dentistry, the global burden of dental caries continues to rise, disproportionately affecting low- and middle-income countries. In Pakistan, recent estimates indicate a high prevalence of dental caries across different age groups, with children being particularly vulnerable due to dietary patterns, suboptimal oral hygiene practices, and inconsistent

**Received**: 17 December 2025
**Revised**: 08 January 2026
**Accepted**: 24 January 2026
**Published**: 30 January 2026

Citation: Click to Cite

exposure to preventive agents such as fluoride (2). This growing burden underscores the importance of effective, evidence-based preventive strategies tailored to pediatric populations.

Fluoride remains the cornerstone of caries prevention and is one of the most extensively studied agents in preventive dentistry. Its anticariogenic effect is primarily topical, achieved through enhancement of enamel remineralization, inhibition of demineralization, and suppression of bacterial metabolic activity within dental plaque (3,4). Fluoride can be delivered through various modalities, including drinking water, professional applications, and self-applied products, with fluoridated toothpaste being the most widely used and cost-effective vehicle for daily fluoride exposure in both children and adults (5,6). International guidelines generally recommend age-appropriate use of fluoridated toothpaste from the eruption of the first tooth, with careful control of fluoride concentration and the amount used to balance caries prevention against the risk of excessive ingestion (7).

In pediatric dentistry, however, fluoride use presents a clinical dilemma. Young children are at increased risk of swallowing toothpaste during brushing, which may contribute to excessive systemic fluoride intake and the development of dental fluorosis, particularly during the critical periods of enamel formation (8). Dental fluorosis ranges from mild, clinically insignificant white opacities to more severe enamel discoloration and structural defects, depending on the dose and duration of fluoride exposure (9). Concerns regarding fluorosis are further complicated in regions where environmental fluoride exposure, such as fluoride levels in drinking water, is variable and not routinely monitored, as is the case in many areas of Pakistan (10). Consequently, dental professionals must rely on accurate knowledge of fluoride guidelines and effective parental counseling to minimize risks while preserving preventive benefits.

Beyond fluoride, pediatric toothpastes contain a wide array of non-therapeutic additives, including flavoring agents, sweeteners, colorants, preservatives, and foaming agents. These ingredients are incorporated primarily to improve taste, appearance, and overall acceptability, thereby enhancing compliance with twice-daily brushing in children (11,12). Evidence suggests that sensory attributes such as flavor, color, and smell significantly influence children's willingness to brush and brushing duration, making these additives a critical component of pediatric oral hygiene products (13). However, the inclusion of such agents has raised concerns regarding their long-term safety, particularly in young children who may ingest toothpaste regularly. Potential issues include mucosal irritation, allergic reactions, and unnecessary systemic exposure to synthetic compounds, although definitive clinical evidence of harm remains limited and inconclusive (14).

In response to fluoride-related concerns, fluoride-free or low-fluoride toothpaste formulations containing alternative remineralizing or antimicrobial agents, such as xylitol, hydroxyapatite, arginine, and herbal extracts, have gained increasing commercial and clinical attention (15,16). Xylitol has demonstrated anticariogenic properties through inhibition of Streptococcus mutans, while hydroxyapatite is a biomimetic agent capable of promoting enamel remineralization without reliance on fluoride (17,18). Despite emerging evidence supporting these agents, their comparative effectiveness, appropriate indications, and role as substitutes or adjuncts to fluoride remain areas of ongoing debate. Importantly, the adoption of such alternatives in clinical practice depends heavily on dental professionals' awareness, perceptions, and confidence in recommending them.

While the efficacy of fluoridated toothpaste in caries prevention is well established, considerably less attention has been paid to dental professionals' knowledge and perceptions regarding optimal fluoride use, age-specific recommendations, and the safety of non-

therapeutic additives in pediatric toothpaste. Existing studies from various regions have reported inconsistent knowledge among dental practitioners regarding recommended fluoride concentrations, appropriate toothpaste quantities for young children, and the timing of fluoride toothpaste initiation (19,20). Moreover, there is a paucity of data from Pakistan exploring how dental undergraduates and practicing dentists perceive both fluoride-related risks and the growing use of non-therapeutic additives in children's oral care products. This gap is particularly relevant given the influential role of dental professionals in guiding parental decision-making and shaping preventive oral health behaviors in children.

Therefore, this study was designed to assess the knowledge, perceptions, and self-reported clinical practices of dental undergraduates and dentists in Pakistan regarding pediatric toothpaste formulations, with a specific focus on fluoride use and non-therapeutic additives. By identifying areas of adequate understanding as well as gaps and misconceptions, this research aims to inform targeted educational interventions and support the development of context-appropriate guidelines for pediatric oral health promotion. The primary objective of this study was to evaluate the level of awareness of recommended fluoride use in children and to explore perceptions and concerns related to flavors and artificial additives among dental undergraduates and practitioners in Pakistan.

## METHODS

This cross-sectional observational study was conducted to evaluate knowledge, perceptions, and self-reported clinical practices related to fluoride use and non-therapeutic additives in pediatric toothpaste among dental undergraduates and practicing dentists in Pakistan. The cross-sectional design was selected as appropriate for estimating the prevalence of awareness, attitudes, and practices within a defined population at a single point in time and for identifying knowledge gaps relevant to preventive oral health care (21). Data collection was carried out over a five-month period from September 2025 to January 2026 and included participants from multiple public and private dental institutions and clinical settings across major urban centers of Pakistan, including Karachi, Islamabad, Lahore, and Faisalabad.

The study population comprised dental undergraduates enrolled in clinical years (second year and above), house officers, general dental practitioners, and postgraduate trainees or specialists actively involved in clinical dental care. Inclusion criteria required participants to be currently enrolled in or graduated from a recognized dental institution and to have direct or indirect exposure to pediatric oral health care through education or practice. Pre-clinical undergraduate students, non-dental healthcare professionals, and incomplete or duplicate survey responses were excluded from the analysis. Participants were selected using a non-probability convenience sampling strategy, which was considered appropriate given the exploratory nature of the study and the absence of a comprehensive national registry of dental professionals.

Recruitment was facilitated through academic networks, professional contacts, and social media platforms commonly used by dental students and practitioners. An invitation message containing a brief description of the study purpose and a secure survey link was disseminated electronically. Participation was entirely voluntary, and informed consent was obtained electronically prior to accessing the questionnaire. Consent was recorded through a mandatory consent item at the beginning of the survey, and only participants who provided consent were allowed to proceed.

Data were collected using a structured, self-administered online questionnaire developed following an extensive review of pediatric dental guidelines and previously published, pre-validated surveys assessing fluoride knowledge and perceptions of toothpaste ingredients

(19,20). The questionnaire was adapted to reflect pediatric toothpaste products commonly available in Pakistan and was reviewed by experienced dental professionals to ensure content validity, clarity, and contextual relevance. Minor modifications were made based on expert feedback prior to dissemination. The final instrument was administered using Google Forms, allowing participants to complete the survey privately at their convenience.

The questionnaire consisted of four integrated domains. The first domain captured demographic and professional characteristics, including age, gender, designation, years of clinical experience, and geographic location of practice or study. The second domain assessed fluoride-related knowledge and perceptions, including awareness of recommended fluoride concentrations for children, appropriate age to initiate fluoridated toothpaste, perceived effectiveness of fluoride in caries prevention, and perceived risk of dental fluorosis. Awareness of fluoride concentration was operationally defined as self-reported familiarity with guideline-recommended fluoride levels for pediatric toothpaste. The third domain explored perceptions and concerns regarding non-therapeutic additives, including artificial sweeteners, flavoring agents, preservatives, colorants, and foaming agents, with responses recorded using a Likert-scale format to assess the degree of concern. The fourth domain evaluated self-reported clinical behaviors, including parental counseling practices, recommendation of fluoride-free alternatives, knowledge of alternative agents such as xylitol and hydroxyapatite, and opinions regarding the need for stricter regulation of pediatric toothpaste formulations.

To minimize information bias, the questionnaire was anonymous, and no personally identifiable information was collected. Questions were phrased in neutral, non-leading language to reduce social desirability bias. Duplicate entries were screened and removed during data cleaning by reviewing response patterns and timestamps. Responses with substantial missing data were excluded prior to analysis. Remaining missing values were minimal and handled through complete-case analysis, as the proportion was insufficient to warrant imputation. Given the descriptive objectives of the study, no adjustments for confounding variables were performed; however, key demographic variables were collected to allow stratified interpretation of findings where relevant.

The sample size was calculated using a standard formula for cross-sectional studies, assuming a 95% confidence level, a 5% margin of error, and an expected population proportion of 50% to maximize sample size in the absence of prior prevalence estimates. The calculated minimum sample size was 377 participants. Although the final analyzed sample comprised fewer respondents, it was considered sufficient to provide stable descriptive estimates of awareness and perceptions within the target population.

Statistical analysis was performed using IBM SPSS Statistics software version 26.0. Data were initially screened for completeness and consistency before analysis. Descriptive statistics, including frequencies, percentages, means, and measures of dispersion, were used to summarize demographic characteristics and response distributions. Given that the primary objective was to describe levels of knowledge, perceptions, and practices rather than to test predefined hypotheses, inferential statistical comparisons were not performed. All results were reported with clear denominators to ensure transparency and interpretability.

Ethical approval for the study was obtained from the Research Ethics and Review Board of the Pride Center for Research and Learning Institute (Reference Number: PRIDE/ERB/2025/031). The study was conducted in accordance with the principles of the Declaration of Helsinki. Participant confidentiality was strictly maintained, data were stored in password-protected files accessible only to the research team, and all analyses were

performed on anonymized datasets. These procedures ensured data integrity, ethical compliance, and reproducibility of the research process.

## RESULTS

A total of 302 responses were received, and 294 were retained for final analysis after removal of incomplete and duplicate entries. The sample was predominantly female (224/294, 76.2%), while males comprised 67/294 (22.9%), and 3/294 (0.9%) did not disclose gender. Most participants reported less than five years of clinical experience (287/294, 97.7%). In terms of professional designation, undergraduate dental students formed the majority (200/294, 67.9%), followed by general dentists (53/294, 17.9%), house officers (30/294, 10.3%), and postgraduate trainees/specialists (11/294, 2.7%). For inferential comparisons, respondents were grouped into undergraduates (n=200) and qualified dentists (house officers, general dentists, and postgraduates combined; n=94).

Regarding fluoride-related knowledge and perceptions, more than three-quarters of participants reported awareness of the recommended fluoride concentration for children (228/294, 77.5%). This awareness differed significantly by professional status: 146/200 undergraduates (73.0%) reported awareness compared with 82/94 dentists (86.3%), indicating higher guideline familiarity among dentists ($\chi^2$=6.41, p=0.011). Belief in fluoride's caries-preventive effect was high across both groups, with 269/294 (91.7%) agreeing or strongly agreeing; the difference between undergraduates (180/200, 90.0%) and dentists (89/94, 93.7%) was not statistically significant ($\chi^2$=0.96, p=0.326). Similarly, concern about fluorosis risk from excessive fluoride exposure was widespread overall (262/294, 89.1%), with comparable proportions among undergraduates (176/200, 88.0%) and dentists (86/94, 90.5%) and no meaningful association with professional status ($\chi^2$=0.37, p=0.541).

Responses also demonstrated variability in recommendations on when to initiate fluoridated toothpaste use. Overall, 123/294 (41.7%) endorsed starting as soon as the first tooth erupts, whereas 46/294 (15.6%) favored delaying use until the child learns to spit. When compared by professional status, dentists showed a higher tendency to recommend starting at first tooth eruption (45/94, 47.4%) than undergraduates (78/200, 39.0%), while undergraduates more frequently preferred delaying until spitting ability develops (36/200, 18.0%) compared with dentists (10/94, 10.5%).

However, this distribution did not reach statistical significance ($\chi^2$=4.12, p=0.248), suggesting that variation in start-age recommendations was not strongly explained by professional grouping alone.

In contrast, a significant difference emerged in recommendations for the amount of toothpaste for children under three years of age. Nearly half of participants supported a smear/rice grain quantity (136/294, 46.4%), while slightly more recommended a pea-sized amount (151/294, 51.3%).

Undergraduates were significantly more likely to recommend a pea-sized amount (116/200, 58.0%) than dentists (43/94, 45.3%), whereas dentists were more likely to recommend the smear/rice grain amount (52/94, 54.7%) compared with undergraduates (84/200, 42.0%). This association was statistically significant ($\chi^2$=7.88, p=0.005), indicating a measurable knowledge or practice gap between groups on age-appropriate toothpaste dosing.

With respect to fluoride-free alternatives and perceptions of non-therapeutic additives, recognition was highest for xylitol (155/294, 52.7%) and hydroxyapatite (149/294, 50.7%). Dentists more often recognized xylitol than undergraduates (57/94, 60.0% vs 98/200, 49.0%), although this did not reach conventional statistical significance ($\chi^2$=3.21, p=0.073). A similar

pattern was observed for hydroxyapatite, recognized by 55/94 dentists (57.9%) versus 94/200 undergraduates (47.0%), again without statistical significance ($\chi^2$=3.08, p=0.079). The most frequently cited concern regarding fluoridated toothpaste was dental fluorosis (171/294, 58.0%), followed by overuse/swallowing (noted in the dataset narrative as 46.7%) and systemic toxicity (27.2%), and the proportion reporting fluorosis as a key concern was similar between undergraduates and dentists (118/200, 59.0% vs 53/94, 55.8%; $\chi^2$=0.28, p=0.596).

*Table 1. Demographic and Professional Characteristics of Participants (n = 294)*

| Variable | Category | Frequency (%) |
|---|---|---|
| Gender | Female | 224 (76.2) |
| | Male | 67 (22.9) |
| | Not disclosed | 3 (0.9) |
| Clinical experience | < 5 years | 287 (97.7) |
| | ≥ 5 years | 7 (2.3) |
| Designation | Undergraduate students | 200 (67.9) |
| | House officers | 30 (10.3) |
| | General dentists | 53 (17.9) |
| | Postgraduate/specialists | 11 (2.7) |

*Table 2. Knowledge and Perceptions Regarding Fluoride Use in Pediatric Toothpaste by Professional Status (n = 294)*

| Variable | Category | Undergraduates n (%) | Dentists n (%) | $\chi^2$ | p-value |
|---|---|---|---|---|---|
| Awareness of recommended fluoride concentration | Yes | 146 (73.0) | 82 (86.3) | 6.41 | 0.011 |
| | No | 54 (27.0) | 13 (13.7) | | |
| Belief that fluoride prevents caries | Agree/Strongly agree | 180 (90.0) | 89 (93.7) | 0.96 | 0.326 |
| | Neutral/Disagree | 20 (10.0) | 6 (6.3) | | |
| Belief that fluoride causes fluorosis | Agree/Strongly agree | 176 (88.0) | 86 (90.5) | 0.37 | 0.541 |
| | Neutral/Disagree | 24 (12.0) | 9 (9.5) | | |

*Table 3. Recommended Age and Amount of Fluoridated Toothpaste by Professional Status*

| Variable | Category | Undergraduates n (%) | Dentists n (%) | $\chi^2$ | p-value |
|---|---|---|---|---|---|
| Start age for fluoride toothpaste | First tooth eruption | 78 (39.0) | 45 (47.4) | 4.12 | 0.248 |
| | After child learns to spit | 36 (18.0) | 10 (10.5) | | |
| Recommended amount (<3 years) | Smear/rice grain | 84 (42.0) | 52 (54.7) | 7.88 | 0.005 |
| | Pea-sized | 116 (58.0) | 43 (45.3) | | |

*Table 4. Perceptions of Fluoride-Free Alternatives and Non-Therapeutic Additives (n = 294)*

| Variable | Category | Total n (%) | Undergraduates n (%) | Dentists n (%) | $\chi^2$ | p-value |
|---|---|---|---|---|---|---|
| Awareness of xylitol | Yes | 155 (52.7) | 98 (49.0) | 57 (60.0) | 3.21 | 0.073 |
| Awareness of hydroxyapatite | Yes | 149 (50.7) | 94 (47.0) | 55 (57.9) | 3.08 | 0.079 |
| Main concern: fluorosis | Yes | 171 (58.0) | 118 (59.0) | 53 (55.8) | 0.28 | 0.596 |
| Belief flavors are essential | Agree | 293 (99.7) | 199 (99.5) | 94 (100.0) | 0.47 | 0.493 |
| Support stricter regulation | Yes | 279 (95.0) | 188 (94.0) | 91 (95.8) | 0.41 | 0.523 |

Perceived importance of flavors for pediatric compliance was nearly universal, with 293/294 participants (99.7%) agreeing that flavors are essential, and no difference by professional status (199/200, 99.5% undergraduates vs 94/94, 100% dentists; $\chi^2$=0.47, p=0.493). Support for stricter regulation of fluoride levels and additives in children's toothpaste was similarly high (279/294, 95.0%) and consistent across groups (188/200, 94.0% vs 91/94, 95.8%; $\chi^2$=0.41, p=0.523). Collectively, these results indicate that while belief in fluoride's benefit is strong and concerns about fluorosis are widespread, measurable group differences exist for guideline-linked knowledge items—most notably recommended toothpaste quantity for children under three—and awareness of fluoride concentration also differs significantly by professional status.

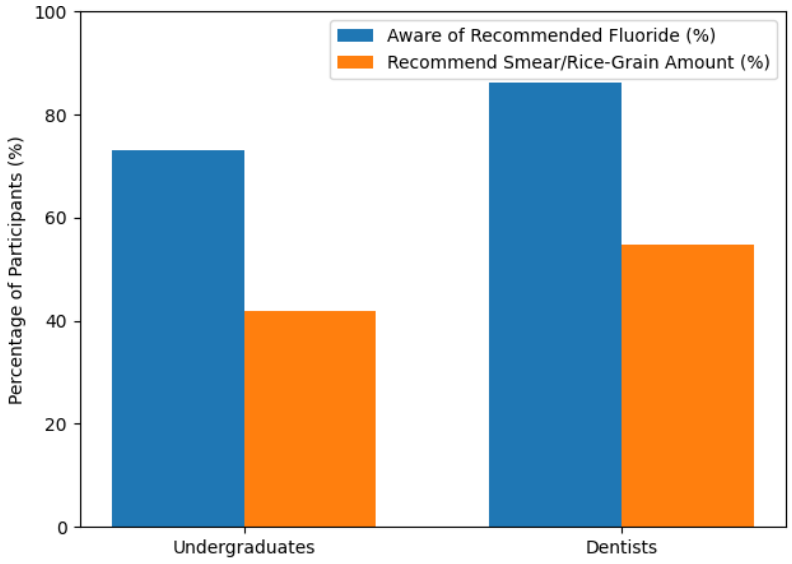


*Figure 1. Professional Gradient in Guideline-Concordant Pediatric Toothpaste Knowledge*

This figure illustrates a clinically meaningful knowledge–practice gradient between undergraduate dental students and qualified dentists by jointly visualizing two guideline-linked indicators that were not previously integrated in tabular form: awareness of recommended pediatric fluoride concentration and recommendation of a smear/rice-grain amount of toothpaste for children under three years. Dentists demonstrated higher awareness of recommended fluoride concentration (86.3%) compared with undergraduates (73.0%), alongside a higher likelihood of recommending the guideline-preferred smear/rice-grain amount (54.7% vs 42.0%). The parallel upward shift across both indicators suggests a consistent professional gradient, indicating that greater clinical exposure is associated with

improved alignment between knowledge and age-appropriate preventive practice. Clinically, this pattern highlights that dosing errors in young children are more prevalent among undergraduates, reinforcing the need for earlier, guideline-focused reinforcement during undergraduate training to reduce fluorosis risk while maintaining caries prevention efficacy.

## DISCUSSION

This cross-sectional study provides a comprehensive assessment of dental undergraduates' and practitioners' knowledge, perceptions, and self-reported practices regarding pediatric toothpaste formulations in Pakistan, with a particular focus on fluoride use and non-therapeutic additives. Overall, the findings demonstrate a strong consensus regarding the caries-preventive benefits of fluoride, alongside substantial concern about the risk of dental fluorosis, reflecting a well-recognized clinical dilemma in pediatric preventive dentistry. However, despite high levels of perceived awareness and positive attitudes toward fluoride, clinically important gaps were identified in guideline-concordant recommendations, particularly concerning age-appropriate toothpaste quantity and initiation of fluoridated toothpaste use.

A key finding of this study was the high level of agreement regarding fluoride's effectiveness in preventing dental caries, reported by more than 90% of participants. This aligns with robust international evidence demonstrating that fluoridated toothpaste significantly reduces caries incidence in children through enhanced remineralization and inhibition of bacterial metabolism (22). The consistency of this belief across both undergraduates and qualified dentists suggests that foundational knowledge regarding fluoride's anticariogenic role is well established within dental education and clinical training in Pakistan. At the same time, the widespread concern about fluorosis risk, expressed by nearly nine out of ten respondents, mirrors findings from other regions where variable environmental fluoride exposure and inconsistent parental supervision during brushing contribute to apprehension about excessive fluoride intake (23).

Importantly, while general awareness of fluoride guidelines was relatively high, significant professional differences were observed. Qualified dentists were more likely than undergraduates to report awareness of recommended fluoride concentrations for children, indicating that clinical exposure and postgraduate experience may reinforce guideline familiarity. Nevertheless, even among dentists, awareness was not universal, highlighting the persistence of knowledge gaps despite professional advancement. This finding is consistent with prior surveys reporting inconsistent understanding of pediatric fluoride recommendations among dental professionals globally (19,20). In the Pakistani context, the absence of routinely monitored water fluoride levels and locally contextualized pediatric guidelines may further contribute to uncertainty and heterogeneous clinical advice.

Variation in recommendations regarding the appropriate age to initiate fluoridated toothpaste use further underscores this ambiguity. Although international guidelines advocate the introduction of fluoridated toothpaste from the eruption of the first tooth using a controlled amount (11), less than half of participants endorsed this recommendation, and a notable proportion preferred delaying use until the child could spit effectively. This divergence likely reflects attempts by clinicians to balance caries prevention against perceived fluorosis risk in the absence of clear national guidance, rather than outright lack of knowledge. Similar discrepancies have been reported in studies from other low- and middle-income settings, where contextual factors influence interpretation and application of global recommendations (24).

The most clinically significant gap identified in this study relates to recommendations for toothpaste quantity in children under three years of age. More than half of participants advised using a pea-sized amount, despite current evidence-based guidelines recommending a smear or rice grain-sized amount to minimize fluoride ingestion (24). This practice was significantly more common among undergraduates than qualified dentists, suggesting incomplete integration of updated recommendations during undergraduate training. The persistence of older guidance advocating pea-sized quantities may contribute to unintentional overexposure in young children, reinforcing the need for curricular updates and targeted educational reinforcement. Given that toothpaste quantity is a modifiable, counseling-dependent factor, this finding has direct implications for reducing fluorosis risk without compromising preventive efficacy.

Beyond fluoride, this study offers valuable insight into dental professionals' perceptions of non-therapeutic additives in pediatric toothpaste. Nearly all respondents emphasized the importance of flavors in promoting child compliance, supporting existing evidence that sensory attributes play a critical role in motivating regular brushing and improving oral hygiene behaviors in children However, this recognition was accompanied by widespread concern about artificial sweeteners, preservatives, colorants, and foaming agents, reflecting growing professional caution toward unnecessary chemical exposure in early childhood. While definitive evidence linking these additives to systemic harm remains limited, concerns regarding mucosal irritation, allergic reactions, and long-term ingestion are increasingly reported in the literature (25).

Awareness of fluoride-free alternatives such as xylitol and hydroxyapatite was moderate, with dentists demonstrating slightly higher recognition than undergraduates. Xylitol's anticariogenic properties and hydroxyapatite's biomimetic remineralization potential are supported by emerging evidence, particularly as adjuncts to conventional preventive strategies (21,25). However, only a small proportion of participants perceived these alternatives as equally effective to fluoride, and most reported recommending them only occasionally. This cautious adoption aligns with current evidence suggesting that while such agents are promising, they should complement rather than replace fluoride in most pediatric populations.

The near-universal support for stricter regulation of fluoride levels and additives in pediatric toothpaste highlights a collective demand among dental professionals for clearer, evidence-based standards. This is particularly relevant in settings where over-the-counter products vary widely in composition and labeling practices. Strengthened regulatory oversight, combined with professional education and parental counseling, could help ensure safer, more consistent preventive care for children. The high rate of reported parental counseling in this study is encouraging; however, the observed inconsistencies in specific recommendations suggest that counseling content may vary substantially in quality and accuracy.

Several limitations should be considered when interpreting these findings. The sample was predominantly composed of undergraduate students with limited clinical experience, potentially limiting generalizability to experienced practitioners. The use of convenience sampling and self-reported data introduces the possibility of selection bias and social desirability bias. Moreover, awareness was assessed through self-report rather than objective testing of guideline knowledge, and environmental fluoride exposure was not measured. Despite these limitations, the study provides a valuable snapshot of prevailing perceptions and practices and identifies actionable gaps that can inform educational and regulatory interventions.

Overall, this study highlights a clear discordance between strong belief in fluoride's preventive benefits and inconsistent application of age-appropriate guidelines in pediatric toothpaste use. Addressing these gaps through updated undergraduate curricula, continuing professional development, and context-specific national guidelines is essential. Future multicenter studies incorporating objective knowledge assessments, water fluoride measurements, and longitudinal designs are warranted to further refine preventive strategies and optimize pediatric oral health outcomes in Pakistan.

## CONCLUSION

This study demonstrates that while dental undergraduates and practitioners in Pakistan largely acknowledge the caries-preventive benefits of fluoride and recognize the importance of flavored pediatric toothpastes for improving compliance, clinically relevant gaps persist in the application of evidence-based guidelines, particularly regarding appropriate toothpaste quantity and timing of fluoride introduction in young children. Significant variation between undergraduates and qualified dentists indicates that increased clinical exposure improves guideline concordance yet does not fully eliminate inconsistencies. Widespread concern about dental fluorosis and non-therapeutic additives highlights the need for clearer, context-specific guidance and stronger regulatory oversight of pediatric toothpaste formulations. Strengthening undergraduate curricula, reinforcing continuing professional education, and disseminating updated, locally relevant preventive guidelines are essential to ensure safe, effective, and uniform pediatric oral health practices across Pakistan.

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## DECLARATIONS

**Ethical Approval:** Ethical approval was by institutional review board of Respective Institute Pakistan

**Informed Consent**: Informed Consent was taken from participants.

**Authors' Contributions:**

Concept: SG, SS, FS, SK; Design: SG, SS, FS, SK; Data Collection: SG, DF, SS, SK, FS; Analysis: FS; Drafting: SG, SS, SK; Supervision: M.F

**Conflict of Interest**: The authors declare no conflict of interest.

**Funding**: This research received no external funding.

**Data Availability**: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

**Acknowledgments**: NA

**Study Registration:** Not applicable.