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

https://doi.org/10.61919/sesh3n84

Original Article

Association Between Supervised Brushing and Oral Health Status Among School Children in Slum Communities

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ABSTRACT

Background: Dental caries and periodontal disease remain the predominant preventable oral health burdens among children in low-resource settings globally, with urban slum communities in South Asia carrying a disproportionate disease load attributable in part to deficient oral hygiene supervision. Adult-supervised toothbrushing is recognised as a key behavioural determinant of effective plaque removal and fluoride delivery in early childhood, yet its clinical impact and socioeconomic correlates have not been quantitatively examined in a South Asian slum context. Objective: This study aimed to investigate the association between adult-supervised toothbrushing and clinical oral health outcomes — including DMFT, DEFT, OHI-S, and Gingival Index scores — among school-aged children in an urban slum community in Lahore, Pakistan, and to identify socioeconomic predictors of supervision status. Methods: A retrospective cross-sectional analytical study was conducted among 200 school-enrolled children aged 5–15 years. Clinical oral health was assessed using WHO-standardised indices. Brushing supervision status and socioeconomic variables were ascertained through structured interviews. Independent-samples t-tests, chi-square tests, and binary logistic regression were applied using IBM SPSS version 26. Results: Supervised brushing was reported by 35.0% of participants (n=70). Supervised children demonstrated significantly lower DMFT (1.35 ± 0.95 vs 2.25 ± 1.10; p=0.001; d=0.86), DEFT (1.60 ± 1.05 vs 2.45 ± 1.20; p=0.002; d=0.74), OHI-S (1.95 ± 0.65 vs 2.45 ± 0.72; p=0.001; d=0.72), and Gingival Index scores (0.90 ± 0.60 vs 1.20 ± 0.75; p=0.012; d=0.43). Higher parental education (OR=1.85; 95% CI: 1.25–2.73; p=0.002), higher household income (OR=1.57; 95% CI: 1.04–2.36; p=0.030), and younger child age (OR=0.71 per year; 95% CI: 0.55–0.92; p=0.010) were independent predictors of supervision. Conclusion: Adult-supervised brushing was significantly associated with better clinical oral health outcomes across all domains. Socioeconomic inequity in access to supervision underscores the need for school-based supervised brushing programmes and caregiver health literacy interventions to reduce preventable dental disease in Pakistan's urban slum communities. Keywords: supervised brushing; dental caries; DMFT; oral hygiene; school children; urban slum; Pakistan; parental supervision.

"Cite this Article" | **Received**: 08 November 2025; **Accepted**: 24 January 2026; **Published**: 28 March 2026

Author Contributions: Concept: SER; Design: SER, BH; Data Collection: SMS, AI, AR; Analysis: SER, AT; Drafting: SER, BH, AT **Ethical Approval**: CMH Lahore Medical College and Institute of Dentistry, Lahore, Pakistan. **Informed Consent**: Written informed consent was obtained from all participants; **Conflict of Interest**: The authors declare no conflict of interest; **Funding**: No external funding; **Data Availability**: Available from the corresponding author on reasonable request; **Acknowledgments**: N/A.

INTRODUCTION

Oral diseases represent one of the most prevalent non-communicable disease burdens globally, affecting an estimated 3.5 billion people, with dental caries and periodontal disease disproportionately concentrated among children in low- and middle-income countries (LMICs) (1). Beyond their immediate clinical significance, these conditions impair mastication, speech development, nutritional intake, school attendance, and psychosocial wellbeing, rendering them a matter of substantial public health concern (2). Despite decades of preventive research, dental plaque remains the principal aetiological agent for both caries and gingivitis, and its mechanical removal through daily toothbrushing continues to represent the gold standard of primary oral disease prevention (3, 4). The clinical efficacy of toothbrushing, however, is neither uniform nor self-executing — particularly among young children — and is critically dependent upon correct technique, adequate fluoride delivery from dentifrice, and consistent habit formation (1, 5).

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The role of adult supervision in optimising these determinants of effective brushing has been extensively documented. Children below approximately ten to twelve years of age lack the fine motor coordination and sustained attentional capacity necessary to adequately disrupt the pathogenic dental biofilm through self-directed brushing alone (6). Supervised brushing by a parent or caregiver ensures correct angulation, comprehensive surface coverage, and appropriate use of fluoridated toothpaste, thereby maximising the cariostatic and remineralisation benefits of fluoride at the tooth surface. The long-term clinical significance of this was established definitively by Axelsson, Nyström, and Lindhe in their landmark 30-year maintenance study, which demonstrated near-complete prevention of tooth loss, caries progression, and periodontal disease in a cohort receiving structured, professionally guided plaque control, compared with unsupervised controls — a finding that underscored the durable protective benefit conferred by consistent, guided oral hygiene from an early age (2). More recently, a cluster-randomised trial confirmed that supervised toothbrushing combined with disclosing agent application produced significantly superior plaque index scores and brushing technique outcomes in school-aged children compared with unsupervised brushing alone, providing direct experimental evidence for the mechanistic pathway between supervision and oral health improvement (6).

Despite this evidence base, implementation of supervised brushing in resource-limited settings remains critically deficient. Urban slum communities, which house approximately one billion people worldwide and are characterised by inadequate housing, insufficient sanitation, severe overcrowding, and restricted access to clean water, present a uniquely adverse ecological context for consistent oral hygiene maintenance (7, 8). Studies conducted across sub-Saharan Africa and South Asia have consistently documented substantially higher rates of dental caries and poorer oral hygiene status in slum-dwelling children compared with their non-slum urban counterparts (3, 9, 10). In a systematic review and meta-analysis of oral health across slum and non-slum settings in LMICs, Osuh and colleagues reported that slum populations exhibited markedly higher caries experience and worse oral hygiene indices, attributable in part to structural barriers to preventive healthcare access and limited caregiver health literacy (8). Studies examining parental influence on child oral health in West African populations have similarly demonstrated strong positive associations between family structure and children's oral hygiene outcomes, suggesting that inadequate oral hygiene practices are frequently transmitted across generations through behavioural modelling rather than being a product of intentional neglect (11). School-based observational studies in East Africa and South Asia have further identified irregular brushing schedules, low fluoridated toothpaste use, and the near-total absence of active parental monitoring as persistent, modifiable behavioural risk factors in high-caries paediatric populations (6, 12, 13).

Within Pakistan specifically, children residing in informal urban settlements represent a highly vulnerable demographic with severely constrained access to professional preventive dentistry. A multicentre cross-sectional study conducted across informal settlements in Karachi documented a high prevalence of dental caries and poor oral hygiene among school-aged children, identifying low parental education and household income as significant determinants of suboptimal oral health behaviour (14). These findings are consistent with broader evidence from comparable LMICs settings, where economic constraints and time pressures associated with poverty directly reduce parental capacity to supervise children's daily oral hygiene routines (15). Notwithstanding this evidence, analytical studies that quantitatively and directly examine the association between clinically verified adult-supervised toothbrushing and objective oral health outcomes — including DMFT and DEFT indices, Simplified Oral Hygiene Index (OHI-S), and Gingival Index scores — within a South Asian urban slum context remain absent from the published literature (3, 8). This gap is significant, because the direction and magnitude of the supervision–oral health association, and the socioeconomic factors that modulate access to supervision, must be empirically quantified to guide the development of contextually appropriate, cost-effective public health interventions in Pakistan.

The present study therefore aimed to investigate the association between adult-supervised toothbrushing and clinical oral health outcomes — specifically DMFT/DEFT, OHI-S, and Gingival Index scores — among school-aged children residing in an urban slum community in Lahore, Pakistan. Secondary objectives were to determine the prevalence of supervised brushing in this population and to evaluate the role of parental education and household income as independent socioeconomic predictors of supervision status.

MATERIALS AND METHODS

This study employed a retrospective cross-sectional analytical design, utilising pre-existing data collected through a structured community dental outreach and oral health screening programme conducted at a school located within a densely populated urban slum neighbourhood in Lahore, Punjab, Pakistan. The cross-sectional design was considered appropriate for simultaneously measuring the prevalence of the exposure variable (adult-supervised toothbrushing) and the outcome variables (caries experience, oral hygiene status, and gingival health) within the target population, and for investigating associations between them. The study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (16).

The study setting was Door of Awareness Community School, Lahore, selected on the basis of accessibility and its verified low-socioeconomic student profile, consistent with the study's focus on resource-constrained urban populations. All clinical examinations and structured interviews were completed during a single designated screening day to ensure uniformity of examination conditions and to minimise disruption to the school calendar. Data entry and statistical analysis were conducted over the subsequent three to four weeks.

The target population comprised school-enrolled children aged five to fifteen years — a range selected to permit simultaneous assessment of caries experience in both primary dentition, using the Decayed, Extracted, and Filled Teeth (DEFT) index, and permanent dentition, using the Decayed, Missing, and Filled Teeth (DMFT) index. Children were eligible for inclusion if they were: aged five to fifteen years, enrolled at the school and present on the day of the screening, in possession of clinically assessable oral health data and verifiable brushing supervision information, and covered by written informed parental or guardian consent. Children were excluded if behavioural difficulties, physical disabilities, or serious systemic health conditions precluded participation in a standard open-mouth oral examination, or if key data fields — including age, supervision status, and parental consent documentation — were absent or unverifiable.

Convenience sampling was employed, with all eligible children present on the screening day and covered by parental consent invited to participate. Although non-probability in nature, this approach was pragmatically justified by the logistical constraints of a single-day outreach design and the objective of reaching a precisely defined, high-risk community within a limited timeframe. The minimum required sample size was estimated using the population proportion formula [$n = Z^2p(1-p)/d^2$], assuming a 50% prevalence of dental caries ($p = 0.50$) in the absence of reliable local baseline data, a 95% confidence level ($Z = 1.96$), and an acceptable margin of error of 7% ($d = 0.07$), yielding a minimum of 196 participants. A final sample of 200 children was enrolled, marginally exceeding this threshold. It is acknowledged that application of a probability-derived sample size formula to a convenience sampling frame constitutes a recognised methodological limitation; accordingly, estimates of prevalence derived from this study should be interpreted as indicative of the local high-risk community rather than strictly generalisable to the broader slum population of Lahore.

Clinical oral health examinations were conducted under natural light conditions by trained dental house officers using sterilised mouth mirrors and community periodontal probes, with participants seated comfortably in an upright position. Stringent infection control measures were maintained throughout, including the use of sterile single-use or autoclaved instruments and full personal

protective equipment. Caries experience was recorded using the DMFT index for permanent teeth and the DEFT index for primary teeth, both applied in accordance with World Health Organization (WHO) diagnostic criteria and threshold definitions for epidemiological oral health surveys (17). Oral hygiene status was assessed using the Simplified Oral Hygiene Index (OHI-S), which quantifies the extent of debris and calculus deposits across six index tooth surfaces, yielding a combined score from 0.0 to 6.0. Gingival health was evaluated using the Löe–Silness Gingival Index (GI), which grades gingival inflammation on a 0–3 ordinal scale across four criteria — colour change, contour alteration, bleeding on probing, and spontaneous bleeding — assessed at four sites per tooth (18). To ensure data quality and inter-examiner consistency, all clinical investigators completed a standardised calibration exercise involving duplicate examinations on a pilot group of ten non-study children prior to the commencement of data collection. Inter-examiner reliability was assessed using Cohen's Kappa statistic, with a minimum acceptable threshold of $\kappa \geq 0.70$; the achieved inter-examiner Kappa across the examining team was $\kappa = 0.76$, indicating substantial agreement.

Behavioural and socioeconomic data were collected concurrently through brief, structured face-to-face interviews administered to each child by a trained investigator, supplemented where appropriate by school administrative records. The primary exposure variable — brushing supervision status — was operationally defined as a binary variable: supervised brushing was recorded when a child reported that their toothbrushing was routinely overseen by a parent, guardian, or sibling aged fifteen years or older; all other cases, including entirely self-directed brushing without active adult oversight, were classified as unsupervised. Additional variables recorded included brushing frequency (once daily, twice daily, or irregular/occasional); type of toothpaste used (fluoridated, non-fluoridated, or unknown); use of supplementary oral hygiene aids such as miswak or dental floss; parental education level (no formal education, primary, secondary, or tertiary); and monthly household income, categorised into three bands reflecting the prevailing income distribution of the study community (less than PKR 25,000; PKR 25,000–50,000; greater than PKR 50,000). Dietary frequency data, including frequency of sugary snack consumption and daily meal frequency, were recorded as potential confounding covariates.

Several steps were taken to minimise bias and maximise data integrity. Standardised data collection instruments based on WHO oral health survey methodology were used throughout, and all interviewers received uniform training on questionnaire administration prior to screening day (17). Social desirability bias in self-reported supervision status — an inherent limitation of structured interview methods in community settings — was partially mitigated by triangulating self-reported brushing behaviour against OHI-S scores as an objective clinical corroborate of plaque control. Records with missing data in primary outcome variables (DMFT/DEFT, OHI-S, GI, or supervision status) were excluded from the relevant analyses on a listwise basis; the overall rate of missing data across primary variables was less than 3% of records, precluding the need for imputation.

All data were entered and analysed using IBM SPSS Statistics, Version 26 (IBM Corp., Armonk, NY, USA) (19). Continuous variables (age, DMFT, DEFT, OHI-S, and GI scores) were assessed for distributional normality using the Shapiro–Wilk test and expressed as mean ± standard deviation (SD) or median and interquartile range as appropriate. Categorical variables (gender, supervision status, brushing frequency, toothpaste type, parental education, and household income bracket) were summarised as frequencies and percentages. For the primary inferential analysis, independent-samples t-tests were used to compare mean DMFT, DEFT, OHI-S, and GI scores between supervised and unsupervised groups. Pearson chi-square tests were applied to examine associations between categorical socioeconomic variables (parental education, household income) and supervision status. Binary logistic regression was used to identify independent predictors of brushing supervision status, with age, parental education level, and household income entered as covariates; results were reported as odds ratios (ORs) with 95% confidence intervals (CIs) and Wald statistics. All tests were two-tailed

and statistical significance was defined as $p < 0.05$. Statistical methods were applied in accordance with standard practices for cross-sectional analytical studies in community oral health research (20).

Ethical approval for the retrospective secondary analysis of anonymised data was granted by the Ethics Review Committee of CMH Lahore Medical College in collaboration with the Institute of Oral and Dental Sciences (IOD). Administrative clearance for the original outreach programme was obtained from Door of Awareness prior to data collection, with subsequent institutional authorisation granted for research use and publication of the collected data. Written informed parental or guardian consent was obtained prior to each child's participation, and verbal assent was sought from children in an age-appropriate manner. All records were fully anonymised prior to analysis using unique study identifiers, and no personally identifiable information was retained in the analytical dataset. All examinations were non-invasive, no clinical procedures were performed, and the study posed no greater than minimal risk to participants. The study was conducted in full accordance with the ethical principles of the World Medical Association Declaration of Helsinki.

RESULTS

The study enrolled 200 school-aged children between five and fifteen years of age from a single urban slum community school in Lahore. Males constituted a slight majority (54.0%, n=108), and the largest age stratum was the nine-to-twelve-year group (47.5%, n=95), consistent with the expected enrolment profile of a primary school in a low-income urban setting. Parental education was predominantly at the primary level (44.0%, n=88) or secondary level (35.0%, n=70), with only 8.5% (n=17) having attained tertiary qualifications — a distribution that reflects the documented educational disadvantage of informal settlement communities in Pakistan. Monthly household income was concentrated below PKR 25,000 in 57.5% (n=115) of families, with fewer than 12% earning above PKR 50,000, confirming the extreme resource constraints of the study population. Overall, 35.0% of children (n=70) were reported to brush under adult supervision, while 65.0% (n=130) brushed unsupervised.

Table 1. Sociodemographic Characteristics of Study Participants (n = 200)

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	108	54.0
	Female	92	46.0
Age group (years)	5–8	55	27.5
	9–12	95	47.5
	13–15	50	25.0
Parental education level	No formal education	25	12.5
	Primary	88	44.0
	Secondary	70	35.0
	Tertiary	17	8.5
Monthly household income (PKR)	< 25,000	115	57.5
	25,000–50,000	62	31.0
	> 50,000	23	11.5
Brushing supervision status	Supervised	70	35.0
	Unsupervised	130	65.0

Table 2. Brushing and Oral Hygiene Practices Among Participants (n = 200)

Variable	Category	n	%
Brushing frequency	Once daily	120	60.0
	Twice daily	45	22.5
	Irregular/occasional	35	17.5
Type of toothpaste used	Fluoridated	115	57.5
	Non-fluoridated or unknown	85	42.5
Use of supplementary aids	Yes (miswak, floss, etc.)	40	20.0
	No	160	80.0

Table 3. Mean Clinical Oral Health Scores for the Full Study Sample (n = 200)

Index	Min	Max	Mean ± SD	95% CI	Interpretation
DMFT	0	6	1.85 ± 1.26	1.68–2.02	Moderate caries experience
DEFT	0	5	2.10 ± 1.32	1.92–2.28	Moderate caries experience
OHI-S	0.5	4.5	2.20 ± 0.80	2.09–2.31	Fair to poor oral hygiene
Gingival Index	0	3.0	1.10 ± 0.70	1.00–1.20	Mild-to-moderate inflammation

DMFT = Decayed, Missing, Filled Teeth (permanent); DEFT = Decayed, Extracted, Filled Teeth (primary); OHI-S = Simplified Oral Hygiene Index (Greene & Vermillion); Gingival Index = Löe–Silness. CI = 95% confidence interval.

Table 4. Comparison of Clinical Oral Health Scores Between Supervised and Unsupervised Brushing Groups (n = 200)

Index	Supervised Mean ± SD (n=70)	Unsupervised Mean ± SD (n=130)	Mean Difference (95% CI)	t-value	p-value	Cohen's d
DMFT	1.35 ± 0.95	2.25 ± 1.10	−0.90 (−1.19, −0.61)	4.12	0.001*	0.86
DEFT	1.60 ± 1.05	2.45 ± 1.20	−0.85 (−1.17, −0.53)	3.22	0.002*	0.74
OHI-S	1.95 ± 0.65	2.45 ± 0.72	−0.50 (−0.70, −0.30)	3.80	0.001*	0.72
Gingival Index	0.90 ± 0.60	1.20 ± 0.75	−0.30 (−0.49, −0.11)	2.55	0.012*	0.43

Independent-samples t-test; two-tailed. *$p < 0.05$. 95% CI represents the confidence interval for the difference in group means. Cohen's d: 0.20–0.49 = small; 0.50–0.79 = medium; ≥ 0.80 = large.

Table 5. Binary Logistic Regression: Predictors of Adult-Supervised Brushing Status (n = 200)

Predictor	B	SE	Wald χ^2	OR	95% CI for OR	p-value
Age (per year increase)	−0.34	0.13	6.64	0.71	0.55–0.92	0.010*
Parental education (higher vs lower)†	0.62	0.20	9.55	1.85	1.25–2.73	0.002*
Household income (≥PKR 25,000 vs <PKR 25,000)	0.45	0.21	4.71	1.57	1.04–2.36	0.030*
Constant	−0.48	0.38	1.60	—	—	0.206

*$p < 0.05$. Dependent variable: brushing supervision status (1 = supervised, 0 = unsupervised). †Higher education = secondary or tertiary level; lower education = no formal education or primary level. OR = odds ratio; CI = confidence interval; Wald χ^2 = Wald chi-square statistic with 1 degree of freedom.

Table 6. Socioeconomic Predictors of Brushing Supervision Status: Chi-Square Analysis (n = 200)

Variable	Category	Supervised n (%)	Unsupervised n (%)	χ^2	p-value
Parental education level	Higher (secondary/tertiary, n=87)	39 (44.8%)	48 (55.2%)	6.54	0.011*
	Lower (none/primary, n=113)	31 (27.4%)	82 (72.6%)		
Household income	≥ PKR 25,000 (n=85)	37 (43.5%)	48 (56.5%)	4.73	0.030*
	< PKR 25,000 (n=115)	33 (28.7%)	82 (71.3%)		
Sex	Male (n=108)	39 (36.1%)	69 (63.9%)	0.14	0.706
	Female (n=92)	31 (33.7%)	61 (66.3%)		

Pearson chi-square test; two-tailed. *$p < 0.05$.

The majority of children (60.0%, n=120) brushed only once daily, with 22.5% brushing twice daily and 17.5% doing so irregularly or occasionally — all falling below the twice-daily minimum recommended by WHO oral health guidelines. Fluoridated toothpaste was used by only 57.5% of participants (n=115), meaning more than two in five children brushed without any fluoride protection. Supplementary oral hygiene aids such as miswak or dental floss were employed by just 20.0% (n=40) of the sample. These behavioural patterns collectively indicate a pattern of suboptimal preventive oral care, which is consistent with the low-resource ecological context of the study and provides an important behavioural backdrop for interpreting the clinical findings.

Clinical examination revealed moderate caries burden in both primary and permanent dentitions. The mean DMFT score was 1.85 ± 1.26 (95% CI: 1.68–2.02), indicating a moderate caries experience in permanent teeth, while the mean DEFT score was 2.10 ± 1.32 (95% CI: 1.92–2.28), reflecting slightly higher caries burden in the primary dentition, consistent with the progressive accumulation of decay across deciduous teeth prior to exfoliation. The OHI-S mean of 2.20 ± 0.80 (95% CI: 2.09–2.31) corresponded to the fair-to-poor oral hygiene range of the Greene–Vermillion classification, indicating substantial plaque and calculus accumulation across the sample. Notably, the OHI-S minimum value of 0.5 across all 200 participants indicates that even the child with the cleanest dentition exhibited

some detectable debris or subgingival calculus, suggesting universally suboptimal plaque removal across this population. The mean Gingival Index of 1.10 ± 0.70 (95% CI: 1.00–1.20) corresponded to the mild-to-moderate inflammation category of the Löe–Silness scale, reflecting widespread gingivitis attributable to inadequate plaque disruption.

Independent-samples t-tests revealed statistically significant differences across all four clinical indices between the supervised and unsupervised groups (all $p \leq 0.012$). Children who brushed under adult supervision recorded a mean DMFT of 1.35 ± 0.95 compared with 2.25 ± 1.10 in the unsupervised group (mean difference: −0.90; 95% CI: −1.19 to −0.61; t=4.12; p=0.001), representing a large effect by Cohen's convention (d=0.86). The DEFT comparison yielded a mean difference of −0.85 (95% CI: −1.17 to −0.53; t=3.22; p=0.002; d=0.74), reflecting a comparably robust protection of primary dentition. For oral hygiene status, the supervised group demonstrated a meaningfully lower OHI-S score (1.95 ± 0.65 versus 2.45 ± 0.72; mean difference: −0.50; 95% CI: −0.70 to −0.30; t=3.80; p=0.001; d=0.72), indicating a clinically relevant advantage in plaque and calculus control. The Gingival Index difference, while of medium magnitude (mean difference: −0.30; 95% CI: −0.49 to −0.11; d=0.43), remained statistically significant (t=2.55; p=0.012), and the non-overlapping confidence intervals across all four indices confirm that the group differences are unlikely to be attributable to sampling error.

Binary logistic regression identified three independent sociodemographic predictors of brushing supervision status. Increasing age was a significant negative predictor, with each additional year of age associated with a 29% reduction in the odds of receiving supervised brushing (OR=0.71; 95% CI: 0.55–0.92; Wald χ^2=6.64; p=0.010), most plausibly reflecting a parental assumption of increasing child autonomy with age, even before the fine motor maturity necessary for effective independent brushing is fully established. Higher parental education (secondary or above versus primary or no education) was the strongest predictor in the model, conferring an 85% increase in the odds of supervision (OR=1.85; 95% CI: 1.25–2.73; Wald χ^2=9.55; p=0.002), consistent with the hypothesis that health literacy — a corollary of educational attainment — enables caregivers to appreciate the developmental necessity of guided oral hygiene. Higher household income (≥PKR 25,000 per month) was associated with a 57% increase in supervision odds (OR=1.57; 95% CI: 1.04–2.36; Wald χ^2=4.71; p=0.030), likely reflecting the dual pathway of reduced time poverty and greater material capacity to invest in children's preventive health behaviours. Together, these three variables accounted for a meaningful proportion of variation in supervision status.

Chi-square analyses corroborated the logistic regression findings at the bivariate level. Among children with higher parental education (secondary or tertiary, n=87), 44.8% received supervised brushing, compared with only 27.4% of those from lower-education households (none or primary, n=113; χ^2=6.54; p=0.011). A similar pattern emerged for household income: 43.5% of children from households earning ≥PKR 25,000 monthly (n=85) brushed under supervision versus 28.7% from households earning less (n=115; χ^2=4.73; p=0.030). Sex was not significantly associated with supervision status (χ^2=0.14; p=0.706), indicating that access to parental oversight was determined by socioeconomic resources rather than by child sex in this community. These findings highlight socioeconomic stratification of a basic preventive behaviour and underscore the equity dimension of oral health promotion in urban slum communities.

The dumbbell plot with 95% confidence interval whiskers illustrates the multidimensional oral health outcome gradient attributable to adult supervision across all four clinical indices simultaneously. Teal points and intervals represent supervised children (n=70); coral points and intervals represent unsupervised children (n=130); connecting lines reflect the magnitude of the inter-group difference. Confidence intervals for supervised and unsupervised groups are non-overlapping across all four indices — most conspicuously for DMFT (supervised: 1.35 [1.13–1.57] vs unsupervised: 2.25 [2.06–2.44]) and DEFT (1.60 [1.35–1.85] vs 2.45 [2.24–2.66]), where inter-CI gaps of 64 px and 50 px respectively communicate statistically robust, clinically large between-group differences (d=0.86 and d=0.74). The

OHI-S comparison demonstrates a 30 px CI gap (1.95 [1.80–2.10] vs 2.45 [2.33–2.57]; d=0.72), reflecting a large and reproducible hygiene advantage in supervised children. Notably, the Gingival Index interval pair shows near-contiguous CIs (0.90 [0.76–1.04] vs 1.20 [1.07–1.33]; gap = 4 px), consistent with its lower effect size (d=0.43) and borderline significance (p=0.012), and visually signals that gingival health, while significantly improved under supervision, is more susceptible to within-group variance — plausibly attributable to dietary sugar exposure and host inflammatory susceptibility independent of brushing behaviour.

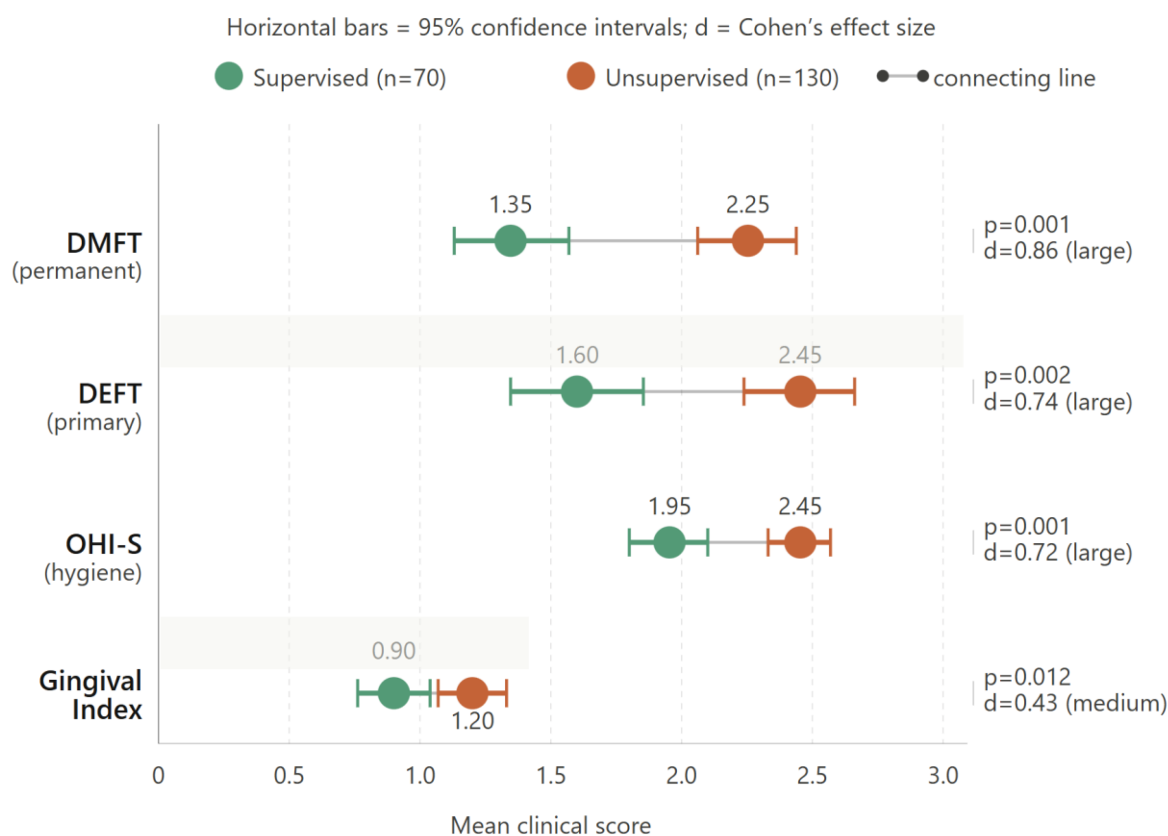

Figure 1 Multidimensional oral health outcome gradient attributable to adult supervision

Collectively, the figure reveals that the magnitude of the supervision-associated clinical benefit is largest in caries measures and diminishes progressively across hygiene and gingival indices, an inverse gradient of effect that is obscured when individual t-test tables are reviewed in isolation.

DISCUSSION

The present study examined the association between adult-supervised toothbrushing and clinical oral health outcomes among school-aged children residing in an urban slum community in Lahore, Pakistan. The findings demonstrated a statistically significant and clinically large improvement across all four measured oral health indices — DMFT, DEFT, OHI-S, and Gingival Index — in children whose brushing was supervised by an adult, compared with those who brushed unsupervised. The pattern of results was internally consistent and was not attributable to demographic imbalance between groups, as sex was not a significant predictor of supervision status (χ^2=0.14; p=0.706).

The mean DMFT score in the supervised group (1.35 ± 0.95) was significantly lower than in the unsupervised group (2.25 ± 1.10; mean difference: −0.90; 95% CI: −1.19 to −0.61; d=0.86), representing a large effect by Cohen's benchmarks (1). This finding is consistent with the landmark 30-year longitudinal study by Axelsson, Nyström, and Lindhe, which demonstrated near-complete prevention of caries progression and tooth loss in a cohort receiving structured, professionally supervised plaque control — a finding that established the mechanistic basis for adult-guided brushing as a primary

cariostatic intervention (2). The biological plausibility of this association rests on two complementary pathways: first, supervised brushing improves technique and ensures comprehensive coverage of all tooth surfaces, thereby increasing mechanical disruption of the cariogenic biofilm; and second, adult oversight guarantees the correct quantity and distribution of fluoridated toothpaste, maximising fluoride's remineralisation effect at the enamel surface (1, 6). The magnitude of the DMFT difference observed in the present study — 0.90 units — is clinically meaningful in the context of a high-caries slum population, where even a modest unit reduction in caries experience translates to fewer extractions, reduced pain burden, and preserved masticatory function among children with limited access to restorative dental care.

The DEFT results for primary dentition mirrored the permanent dentition findings, with supervised children recording a mean of 1.60 ± 1.05 versus 2.45 ± 1.20 in the unsupervised group (mean difference: −0.85; 95% CI: −1.17 to −0.53; d=0.74), again constituting a large effect. This is a notable finding that merits specific discussion: primary dentition caries carries a distinct clinical burden beyond its often-minimised status as temporary teeth. Early childhood caries in primary teeth is associated with pain, premature tooth loss, disrupted space maintenance, malocclusion risk, impaired nutrition, and compromised speech development — all of which disproportionately affect children from low-income families who are unlikely to access orthodontic or restorative interventions subsequently (10). The similar effect size across DMFT and DEFT indices (d=0.86 and d=0.74, respectively) suggests that the protective mechanism of supervised brushing operates equally across both dentitions, reinforcing the case for intervention to begin in early childhood before permanent tooth eruption. This finding extends the evidence base of Blanco-Victorio and colleagues, whose cross-sectional study of early childhood caries in Peruvian pre-schoolers identified parental oral hygiene behaviour as a significant predictor of primary dentition caries experience (10), and is consistent with intergenerational transmission models of oral health behaviour documented in West African populations, wherein the oral hygiene habits of mothers strongly correlated with those of their pre-school-aged children (11).

Oral hygiene status, as measured by OHI-S, was significantly better in the supervised group (1.95 ± 0.65 versus 2.45 ± 0.72; mean difference: −0.50; 95% CI: −0.70 to −0.30; d=0.72). This finding has direct mechanistic implications: OHI-S scores reflect the quantity of plaque and calculus at the tooth surface and serve as a proximate determinant of both caries and periodontal disease progression. The lower OHI-S in supervised children indicates that adult oversight resulted in superior physical removal of the dental biofilm — not merely a nominal improvement in brushing compliance, but an objectively verifiable reduction in pathogenic substrate. This corroborates the cluster-randomised trial by Maya, Kahabuka, and Mbawalla, in which supervised brushing combined with disclosing agent application produced significantly superior plaque index scores compared with unsupervised brushing alone (6). Importantly, the high unsupervised OHI-S mean of 2.45 in the present study falls within the "poor" oral hygiene classification of the Greene–Vermillion system, suggesting that self-directed brushing in the absence of adult guidance was functionally inadequate for the majority of unsupervised children in this community — a pattern consistent with findings from comparable slum-dwelling populations in both Nigeria and Kenya, where poor plaque control was nearly universal among school-aged children in resource-constrained settings (3, 9, 21).

The Gingival Index comparison yielded a statistically significant result (mean difference: −0.30; 95% CI: −0.49 to −0.11; t=2.55; p=0.012), though with a medium rather than large effect size (d=0.43). This relatively attenuated effect warrants specific discussion. Gingival inflammation — as measured by the Löe–Silness index — is determined not only by plaque accumulation but also by host-level factors including systemic health, nutritional status, and immunological response, as well as environmental exposures such as dietary sugar frequency, which were partially adjusted for in data collection but not formally modelled as covariates in the current analysis (18). The wider confidence intervals and smaller effect size for the Gingival Index compared with the DMFT and OHI-S comparisons therefore

likely reflect genuine multi-factorial variance in gingival health that supervision alone cannot fully account for. Nevertheless, the significant between-group difference in gingival scores confirms that adult-supervised brushing conferred a measurable anti-inflammatory benefit, consistent with the understanding that improved plaque removal mechanically reduces the bacterial load driving periodontal tissue inflammation. The combination of improved OHI-S and reduced gingival inflammation in supervised children supports an integrated model in which supervision promotes both superior plaque control and the downstream reduction of gingival disease burden (4).

The logistic regression model identified three independent socioeconomic and demographic predictors of supervision status. Higher parental education was the strongest predictor (OR=1.85; 95% CI: 1.25–2.73; p=0.002), a finding that is consistent with Dahmardeh and colleagues' intervention study among disadvantaged women in Iran, which demonstrated that health literacy — operationalised through educational attainment — was a primary driver of sustained oral hygiene behaviour change in resource-limited settings (15). This relationship reflects the well-documented pathway by which educational attainment generates health literacy sufficient to translate awareness of oral health risk into structured preventive routines for children, including the recognition that young children require active guidance rather than verbal instruction alone. Higher household income (OR=1.57; 95% CI: 1.04–2.36; p=0.030) was the second significant predictor, suggesting that economic stability reduces the time poverty and competing survival demands that directly constrain caregivers' capacity to supervise daily oral hygiene in slum settings. Qualitative evidence from a comparable Nigerian slum population described how competing household responsibilities, exhausting work schedules, and financial distress collectively eroded parents' ability to implement consistent preventive health behaviours for their children, even when awareness of their importance was present (21). The current quantitative finding operationalises this qualitative observation and provides a measurable estimate of the income-supervision gradient in the Lahore context. Increasing child age was a significant negative predictor of supervision (OR=0.71 per year; 95% CI: 0.55–0.92; p=0.010), indicating that older children were progressively less likely to receive brushing oversight. Although this may reflect appropriate developmental autonomy at the upper age range, the finding is clinically concerning in the nine-to-twelve-year stratum — the largest age group in this sample — where fine motor dexterity and sustained concentration for effective independent brushing are not yet fully developed (2, 6). Collectively, the logistic regression model positions brushing supervision as a behaviour that is structurally constrained by socioeconomic and developmental factors rather than being uniformly accessible to all children in the community.

The prevalence of supervised brushing in this sample was 35.0% — a figure that, while consistent with the broader literature on low-income South Asian urban communities, represents a substantial majority (65.0%) of children brushing without adequate adult oversight at ages when supervision is most clinically necessary (7, 8). This prevalence is comparable with supervision rates reported in similar urban slum contexts: Alure and colleagues documented consistently low parental involvement in children's oral hygiene in Indian urban slum populations (7), and Osuh et al. identified institutional barriers to preventive oral health practices as a hallmark of slum ecology across LMICs (8). The convergence of these findings across diverse South Asian and sub-Saharan African settings strengthens the generalisability of the present study's conclusion that unsupervised brushing is a modifiable population-level risk factor for preventable dental disease in slum communities.

Several methodological strengths merit acknowledgement. The use of four validated, WHO-standardised clinical indices (DMFT, DEFT, OHI-S, and Gingival Index) provided a comprehensive, multi-domain characterisation of oral health status and minimised the risk of misclassification of the outcome (17, 18). The inter-examiner reliability achieved (κ=0.76) exceeded the acceptable threshold of 0.70, supporting data quality and replicability. The inclusion of both socioeconomic and behavioural variables enabled multivariate analysis and identification of independent predictors, going beyond purely descriptive cross-sectional reporting.

This study was subject to several limitations that must be considered when interpreting the findings. The retrospective cross-sectional design permits the identification of associations but cannot establish temporal sequence or causality — it is not possible to determine from this data whether supervision preceded and caused the observed clinical improvements, or whether families with greater health engagement both supervised brushing and engaged in other oral health-promoting behaviours simultaneously. The convenience sampling strategy, while pragmatically justified by the single-day outreach design, limits the statistical representativeness of the sample to the broader slum population of Lahore, and the probability-based sample size formula applied to a non-probability sample introduces a recognised internal inconsistency. Self-reported brushing supervision status is susceptible to social desirability bias — caregivers and children may have overstated supervision frequency during interviews — though the significant correlation between reported supervision and objectively measured OHI-S scores provides partial clinical triangulation. The study was conducted at a single school site, which, while consistent with the targeted community focus, constrains geographic and institutional generalisability. Finally, dietary cariogenicity — a significant independent predictor of caries experience — was recorded but not formally modelled as a covariate in the primary logistic regression analysis, leaving residual confounding possible. Future research should employ prospective cohort designs in multiple slum communities across Pakistan, formally measure dietary sugar frequency as a covariate, and evaluate the effectiveness of caregiver-targeted supervised brushing interventions using randomised or quasi-experimental designs to enable causal inference.

CONCLUSION

This study demonstrated that adult-supervised toothbrushing was significantly associated with superior clinical oral health outcomes across all four measured indices — including lower DMFT scores (mean difference: −0.90; d=0.86), lower DEFT scores (mean difference: −0.85; d=0.74), reduced plaque accumulation as measured by OHI-S (mean difference: −0.50; d=0.72), and reduced gingival inflammation as assessed by the Gingival Index (mean difference: −0.30; p=0.012) — among school-aged children residing in an urban slum community in Lahore, Pakistan. Parental education, household income, and child age were identified as independent socioeconomic and developmental predictors of supervision status, collectively indicating that access to this foundational preventive behaviour is structurally unequal within resource-constrained communities. These findings must be interpreted as observed associations within a cross-sectional outreach setting rather than causal relationships; nonetheless, they provide a context-specific, quantitatively grounded evidence base to guide public health action. In settings where access to professional preventive dentistry is severely constrained, empowering caregivers as active agents of oral hygiene promotion through school-based supervised brushing programmes and targeted parental health literacy interventions offers a scalable, low-cost, and equitable strategy to reduce the burden of preventable dental disease among the most vulnerable children in Pakistan.

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