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Cliffland Mosoti, Elizabeth Dimba, Micah Matiang'i

Corresponding author: Cliffland Mosoti, Department of Community Health, Amref International University, Nairobi, Kenya. mosoticliffland@gmail.com

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Prevalence and associated determinants of oral health conditions among sicklers aged 10-18 in Western Kenya

Cliffland Mosoti[1,&], Elizabeth Dimba[2], Micah Matiang'i[1]

[1]Department of Community Health, Amref International University, Nairobi, Kenya, [2]Department of Dental Sciences, University of Nairobi, Nairobi, Kenya

[&]**Corresponding author**
Cliffland Mosoti, Department of Community Health, Amref International University, Nairobi, Kenya

Abstract

Introduction: *Sickle Cell Disease (SCD) presents a major public health challenge in sub-Saharan Africa, with high childhood prevalence in Kenya. Oral health complications in SCD are common yet poorly documented, especially in resource-limited settings. This study assessed the prevalence and determinants of oral health conditions among children with SCD in Kisumu County.* ***Methods:*** *a cross-sectional study included 355 children (10-18 years) with SCD from six Kisumu County clinics, selected via systematic sampling. Data collection used structured questionnaires and clinical examinations (caries: decayed, missing, and filled teeth (DMFT)/dmft index; plaque: Turesky´s modified index). SPSS v30 analyzed data, using multiple regression to identify predictors.* ***Results:*** *dental caries prevalence was 40% (mean DMFT=1.09, primarily decayed teeth). Plaque affected 98% (mean score=1.74); 68.7% had moderate/severe plaque. Most (79.4%) had never visited a dentist; only 6.2% received professional cleaning. Barriers to care affected 89.6%, mainly cost (51.8%) and inaccessibility (35.2%). Significant caries predictors included limited facility access (OR=0.25) and motivation for healthy teeth (OR=11.06). Plaque and DMFT are significantly associated with caregiver occupation, brushing frequency, fluoride use, and dental visit history.* ***Conclusion:*** *oral health conditions are highly prevalent among children with SCD in Kisumu County, strongly linked to limited care access, low socioeconomic status, and inadequate self-care. Integrating oral health promotion and services into SCD care programs is urgently needed.*

Introduction

Sickle Cell Disease (SCD) is a hereditary hemoglobinopathy marked by the presence of hemoglobin S, which distorts red blood cells into a sickle shape under deoxygenated conditions. These morphological changes impair microvascular circulation and oxygen delivery, contributing to a wide range of systemic complications, including pain crises, anemia, and end-organ damage [1]. Although substantial clinical research has addressed the systemic effects of SCD, its impact on oral health remains underexplored, particularly in low- and middle-income countries where access to dental services is limited [2]. In Kenya, the epidemiological burden of SCD is unevenly distributed, with carrier rates ranging between 20-30% in the Lake Victoria basin and up to 35% in coastal counties. There is a higher concentration of haemoglobinopathies in areas near Lake Victoria compared to areas further away from the lake [3]. Despite these high prevalence rates, national health priorities have historically focused on communicable and maternal-child health conditions, leaving chronic genetic disorders like SCD underrepresented in public health planning.

Emerging evidence suggests that individuals with SCD are at heightened risk for oral complications [4]. Documented manifestations include mucosal pallor, delayed tooth eruption, pulp necrosis, and increased susceptibility to infections [4]. These conditions often co-occur with systemic inflammation, vascular insufficiency, and nutritional deficits, creating a complex interplay that may exacerbate oral disease. Moreover, social determinants such as poverty, poor health literacy, and limited geographic access further constrain opportunities for preventive care. Studies exploring the relationship between SCD and dental caries have yielded mixed findings. While some researchers suggest a protective effect due to frequent antibiotic use, others report increased caries prevalence, attributing it to enamel hypoplasia, altered salivary composition, and inconsistent oral hygiene [5]. A Brazilian cohort study further demonstrated that children from low-income families with SCD exhibited significantly higher caries scores, reinforcing the intersection of clinical vulnerability and socioeconomic disadvantage [6]. In the Kenyan context, national data from the Kenya National Oral Health Survey [7] highlight persistent gaps in access to dental care - particularly among adolescents, a group often overlooked in oral health policy and programming. Given the

compounded vulnerabilities faced by adolescents living with SCD, there is a pressing need for context-specific data to inform integrated care models. This study, therefore, aimed to assess the prevalence and determinants of oral health conditions - specifically dental caries and plaque accumulation - among adolescents with SCD in Kisumu County, Kenya. By generating locally relevant evidence, this analysis seeks to contribute to policy and clinical strategies that promote equitable oral health outcomes for medically underserved youth.

Methods

Study design: a descriptive cross-sectional study was conducted [8,9] to assess the prevalence and determinants of oral health conditions of sicklers aged 10-18 years in Kisumu County.

Study setting and population: Kisumu County is an administrative unit in the Western part of Kenya. The county has both an urban and a rural population. The study was piloted from 3rd to 6th February 2025. Data was collected from 12th February 2025 to 27th March 2025. Data were collected from seven purposively selected SCD clinics, including Jaramogi Oginga Odinga Teaching and Referral Hospital, Kisumu County Referral Hospital, Katito Sub-County Hospital, Kisumu Specialist Hospital, Synergy Clinics, Salama Cancer Centre, and Taiba Hospital. These facilities represented both public and private providers, enabling a socioeconomically diverse sample. We set a lower age limit of 10 years to ensure cooperation for clinical examination and an upper age limit of 18 years, informed by trends of loss to follow-up in the clinic.

Variables: variables included age, gender, socioeconomic factors as independent variables, dental caries, periodontal disease, and mucosal diseases as dependent variables, and oral hygiene practices, quality of life, and dietary habits as modifier variables. We considered possible confounders in our analysis, such as differences in oral hygiene practices and socioeconomic factors.

Data resource and measurement

Data collection tools: data were collected through interviewer-administered modified WHO questionnaire and clinical oral examinations using a revised WHO clinical examination form [10].

Data collection: the questionnaire captured socio-demographic data, oral hygiene practices, and access to care. Clinical examinations were performed by a licensed dental surgeon. Dental caries were assessed using the DMFT/dmft index, in accordance with WHO protocols [10], while plaque accumulation was evaluated using Turesky´s modification of the Quigley-Hein Plaque Index [11]. Pre-testing was conducted on 5% of the sample to validate content and administration. Inter- and intra-examiner reliability were assessed using Cohen´s kappa coefficient [12], while the internal consistency of the questionnaire was evaluated using Cronbach´s alpha [13], with $\alpha \geq 0.70$ set as the threshold for acceptability [14]. Questionnaire and clinical data were digitized using Kobo Collect and relayed electronically. Data was stored in a password-protected laptop, followed by data cleaning and analysis using the same laptop.

Sample size: the target sample size of 355 was determined using a single population proportion formula, based on an estimated 30% caries prevalence, 95% confidence interval [15], and 5% margin of error, adjusted upward by 10% to account for non-response [16]. Systematic sampling was employed within the sickle cell disease clinics. Every third patient attending the clinic was selected, beginning from a randomly chosen starting point within each clinic´s schedule [17].

Data analysis: variables with missing data were discarded. Data analysis was done using SPSS version 30 for analysis. Descriptive statistics were used to summarize key variables. Bivariate associations were examined using Pearson´s chi-square tests, and variables with p-values <0.05 were entered into logistic regression models to

identify predictors of caries and plaque severity. Statistical significance was set at $p<0.05$.

Ethical consideration: this study was approved by Amref Ethics Scientific Review Committee (ESRC P1757/2024), and a research permit was sought from the National Commission for Science, Technology and Innovation (NACOSTI) before commencement of the study. Assent and parental consent were obtained for children under the age of 18 years, and consent was obtained from participants aged 18 years. Privacy was upheld during the oral examination, and the data were kept confidential throughout the study.

Results

Socio-demographic characteristics: a total of 355 adolescents aged 10 to 18 years with confirmed sickle cell disease (SCD) participated in the study. The sample included 138 males (38.9%) and 217 females (61.1%). The mean age of participants was 13.3 years (SD = 2.47), with males averaging 13.53 years (SD = 2.51) and females 13.15 years (SD = 2.44). The age group with the highest frequency was 12 years (28.2%), followed by 10 years (13.5%), 13 years (13.2%), and 18 years (11.5%). Participants aged 16 and 17 years each represented 4.5% of the sample. Nearly half (49.0%) of the adolescents were in early adolescence (10-12 years). Regarding education, 69.6% (n = 247) of participants had completed primary education, and 30.4% (n = 108) had reached the secondary level. The majority (91.0%, n = 323) were currently attending school. The occupational status of caregivers showed that 62.5% (n = 222) were self-employed, 23.4% (n = 83) were unemployed, and 14.1% (n = 50) were formally employed (Table 1). All adolescents (100.0%) were on prescribed SCD-related medication.

Oral hygiene practices and dental visits: among participants, 65.6% (n = 233) reported brushing their teeth once daily, 31.0% (n = 110) brushed twice daily, 1.1% (n = 4) brushed three times daily, and 2.3% (n = 8) did not brush at all. Most participants (88.7%, n = 315) used fluoride toothpaste; 11.3% (n = 40) did not, and 15.5% were unsure of the fluoride content. Brushing duration varied: 46.2% (n = 164) brushed for two minutes, 42.8% (n = 152) for one minute or less, and 11.0% (n = 39) for three minutes or more. Regular flossing was reported by 1.4% (n = 5), and 0.8% (n = 3) used mouthwash. A total of 79.4% (n = 282) had never visited a dentist. Among those who had visited a dentist, 13.5% (n = 48) had done so within the past year, 6.2% (n = 22) within the past six months, and 0.8% (n = 3) within the past five years. Regarding frequency, 5.1% (n = 18) reported annual visits, 4.5% (n = 16) quarterly, and 11.0% (n = 39) only when experiencing dental problems. Professional dental cleaning had been received by 6.2% of adolescents.

Dietary habits: daily consumption of sugary foods or drinks was reported by 48.5% (n = 172) of participants. Additionally, 26.5% (n = 94) consumed sugary items 2-3 times weekly, 17.5% (n = 62) 4-6 times weekly, and 7.6% (n = 27) rarely (once weekly or less). For acidic foods and drinks, 10.7% (n = 38) reported daily consumption, 49.9% (n = 177) 2-3 times weekly, 36.9% (n = 131) once weekly or less, and 2.5% (n = 9) 4-6 times weekly.

Oral health knowledge: responses indicated that 31.8% (n = 113) had very little understanding of oral hygiene, 46.2% (n = 164) had limited knowledge, 18.6% (n = 66) had moderate knowledge, and 3.4% (n = 12) reported good knowledge (Table 2). Most participants (92.4%, n = 328) were unaware of the relationship between SCD and oral health. Only 2.0% (n = 7) had received SCD-specific oral health education.

Oral health outcomes: the prevalence of dental caries was 40.0% (n = 142). Among all participants, 98.3% showed measurable plaque accumulation, with 47.9% (n = 170) classified as moderate, 29.3% (n = 104) as mild, and 20.8% (n = 74) as severe. Only 2.0% (n = 7) had no plaque. The mean plaque index was 1.74 (SD = 0.82). The mean DMFT score was 1.09 (SD = 1.41). Specifically, 40.0% (n = 142) had decayed teeth, with a mean of 0.86 (SD =

1.21) and a decayed component mean of 0.94 (Table 3). Among those with dental caries, 82.4% had untreated decay. Missing teeth were observed in 13.8% (n = 49), with a mean of 0.16 (SD = 0.49), and 6.8% (n = 24) had filled teeth, with a mean of 0.10 (SD = 0.35). Mucosal conditions were present in 22.3% (n = 79) of participants. Types observed included angular cheilitis (30.4%, n = 24), aphthous ulcers (29.1%, n = 23), oral candidiasis (24.1%, n = 19), and gingivitis (16.5%, n = 13). As illustrated in Table 3, Chi-square tests revealed significant associations between oral health outcomes and select socio-demographic variables. Caregiver employment status was significantly associated with the presence of untreated decay (χ^2= 12.341, p = 0.006). Geographic access showed significant associations with dental visit frequency (χ^2= 10.455, p = 0.015). Logistic regression identified that children living in peri-urban areas had higher odds of untreated dental caries (OR = 2.84, 95% CI: 1.56-5.17, p = 0.001). Adolescents whose caregivers were unemployed had an increased likelihood of poor oral health outcomes (OR = 2.27, 95% CI: 1.12-4.59, p = 0.023).

Oral health symptoms and severity: all participants (100%) reported experiencing SCD-related health complications in the past year. Reported oral symptoms over the past six months included gum bleeding (48.5%, n = 172), sensitivity to hot or cold foods (38.6%, n = 137), difficulty chewing or swallowing (31.5%, n = 112), toothache (24.8%, n = 88), bad breath (17.5%, n = 62), and mouth sores (15.2%, n = 54). Severity ratings for toothache (n = 88) were as follows: 55.7% moderate, 23.9% mild, 15.9% severe, and 4.5% very severe. For gum bleeding (n = 172), 48.8% rated it as mild, 42.4% as moderate, and 8.7% as severe. Lack of oral health knowledge was significantly associated with the presence of plaque and untreated decay (OR = 2.65, 95% CI: 1.41-4.97, p = 0.003) (Table 4).

Oral health-related quality of life: the majority of participants (61.4%, n = 218) reported no impact of oral health on daily activities. Others reported slight (30.1%, n = 107), moderate (7.9%, n = 28), or significant effects (0.6%, n = 2). Embarrassment or self-consciousness related to oral health was reported by 11.3% (n = 40), while 7.9% (n = 28) avoided smiling or laughing for the same reason. Sleep interference due to oral health problems was reported by 23.9% (n = 85). Satisfaction ratings on a 10-point scale showed that 69.6% (n = 247) rated their satisfaction between 6 and 8 (Table 5).

Discussion

The study identified a substantial burden of oral health conditions among adolescents with SCD in Kisumu County. The prevalence of dental caries was 40.0%, with a mean DMFT score of 1.09, predominantly driven by untreated decay. Plaque was observed in 98.0% of participants, with over two-thirds presenting moderate to severe accumulation, indicating poor oral hygiene and elevated risk of periodontal disease. Knowledge of oral health prevention was generally low, with 98.0% of participants reporting no prior exposure to targeted oral health education. Self-care practices were suboptimal; most children brushed once daily, and very few reported the use of adjunctive hygiene measures. Access to dental services was limited, with 79.4% having never visited a dentist. Multivariate analysis revealed significant associations between oral health outcomes and factors such as age, education level, brushing frequency, fluoride toothpaste use, and caregiver occupation. Socioeconomic status emerged as a key determinant, influencing both behavior and access to care. These findings underscore the need for integrated interventions addressing both clinical and social determinants of oral health in this high-risk population.

The caries prevalence of 40.0%, marked by a high proportion of untreated lesions (82.4%), aligns with evidence attributing caries in SCD to enamel defects, salivary dysfunction, and medication effects [18]. Consistent with studies in similar populations, the predominance of decay within DMFT scores indicates substantial unmet treatment needs. Plaque accumulation was

widespread (98.3%) with a moderate severity index (mean = 1.74), in keeping with findings that link chronic inflammation and immune dysregulation in SCD to increased periodontal vulnerability [19,20]. Mucosal conditions, including gingivitis and angular cheilitis, support earlier observations of elevated oral morbidity in this group [4].

Frequent sugar intake is a well-established risk factor for dental caries, supporting existing evidence on the strong association between diet and oral health outcomes [21]. While Brandão *et al.* [6] reported higher DMFT scores among children with sickle cell disease (SCD), findings across the literature remain inconsistent, indicating a complex and multifactorial relationship between SCD and dental health [22]. Notably, oral health knowledge among participants was limited, with the majority reporting poor understanding, and formal education specific to SCD-related oral care was uncommon. These findings underscore the urgent need for targeted educational interventions in line with recommendations from the World Health Organization.

The majority of participants practiced suboptimal oral hygiene, with the majority brushing once daily, while others brushed for one minute or less, below recommended standards. Supplementary practices such as flossing and mouthwash use were nearly absent. These patterns are consistent with the literature, indicating widespread deficiencies in oral hygiene among individuals with chronic conditions. Dental care utilization was extremely low, with the majority never having visited a dentist and only 13.5% having received care in the past year. Preventive services, such as professional cleaning, were rare. Compared to international figures for children with special healthcare needs, these findings reveal pronounced disparities and confirm access barriers noted in previous work [23].

The association between socioeconomic status and oral health outcomes was statistically significant, consistent with findings by Vozza *et al.* [24]. Access barriers were reported by the majority of participants, with cost and distance being the most cited. These were more pronounced among lower-income households, affirming the social gradient in healthcare access [25]. Caregiver occupation was significantly associated with caries experience ($p < 0.001$), further underscoring the socioeconomic dimension of oral health [26].

The limitation of this study was that we could not establish a cause-and-effect relationship between the dependent and independent variables or track changes over time since this was a cross-sectional study. The questionnaire was self-reported, which is prone to bias, and the clinical exam was done at a single point in time; hence no possibility to track changes over time that affect the generalizability of the results.

Conclusion

This study demonstrated a high burden of oral health diseases among adolescents with sickle cell disease in Kisumu County, with dental caries, plaque accumulation, and mucosal conditions as clinical indicators. Poor oral hygiene practices, infrequent dental visits, and limited access to oral health education were prevalent. Socioeconomic factors, including caregiver occupation and household income, significantly influenced oral health outcomes, while structural barriers such as distance to care and cost further constrained service utilization. These results reinforce the need to integrate oral health promotion into routine SCD care and to address systemic barriers that limit access to preventive and curative services.

What is known about this topic

- *Sickle Cell Disease (SCD) is a significant public health challenge in sub-Saharan Africa, with a high prevalence among children in Kenya;*
- *Oral health complications are common in individuals with SCD;*

- *Despite their commonality, oral health complications in SCD patients are poorly documented, particularly in resource-limited settings.*

What this study adds

- *This study provides specific prevalence rates for dental caries (40%) and plaque accumulation (98%) among children with SCD in Kisumu County, Kenya;*
- *It identifies key determinants of oral health conditions in this population, including limited access to care due to high cost and inaccessibility, low socioeconomic status (caregiver occupation), and inadequate self-care practices (brushing frequency, fluoride use, dental visit history);*
- *The study highlights the urgent need for integrated oral health promotion and service delivery within existing SCD care programs in the region.*

Competing interests

The authors declare no competing interests.

Authors' contributions

All the authors contributed to the conception and design of the study, as well as the acquisition, analysis, and interpretation of the data. They also drafted and critically revised the manuscript. All authors provided their final approval and agreed to take responsibility for all aspects of the work. They also read and approved the final version of this manuscript.

Tables

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Table 5: regression analysis on determinants of oral health among adolescents with sickle cell disease in Kisumu County, collected between February 2025 to March 2025 (N=355)

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Table 1: socio-demographic characteristics of adolescents with sickle cell disease, Kisumu County, recruited in SCD clinics from February 2025 to March 2025 (N=355)

Category	Subcategory	Frequency (n)	Percentage (%)
Age distribution (in years)			
	10	48	13.5
	11	26	7.3
	12	100	28.2
	13	47	13.2
	14	37	10.4
	15	24	6.8
	16	16	4.5
	17	16	4.5
	18	41	11.5
Gender			
	Male	138	38.9
	Female	217	61.1
Education level			
	Primary	247	69.6
	Secondary	108	30.4
School attendance			
	Yes	323	91.0
	No	32	9.0
Caregiver occupation			
	Employed	50	14.1
	Self-employed	222	62.5
	Unemployed	83	23.4

Table 2: oral health knowledge levels and associated socio-demographic factors among adolescents with sickle cell disease collected in SCD clinics in Kisumu from February 2025 to March 2025 (N=355)

Variable	**Category**	**Oral health knowledge levels (%)**	**Knowledge presence (%)**	
		Very little	**Limited**	**Moderate**
Age (years)	10	41.7	33.3	25.0
	11	26.9	30.8	42.3
	12	28.0	59.0	13.0
	13	38.3	48.9	12.8
	14	51.4	45.9	2.7
	15	33.3	37.5	29.2
	16	18.8	68.8	12.5
	17	12.5	31.3	37.5
	18	19.5	39.0	19.5
	Total	31.8	46.2	18.6
Gender	Male	29.0	42.0	24.6
	Female	33.6	48.8	14.7
	Total	31.8	46.2	18.6
Education level	Primary school	34.4	47.8	17.4
	Secondary school	25.9	42.6	21.3
	Total	31.8	46.2	18.6
Occupation	Employed	20.0	22.0	50.0
	Self-employed	32.4	50.0	15.3
	Unemployed	37.3	50.6	8.4
	Total	31.8	46.2	18.6

Table 3: prevalence of dental caries, plaque severity, and mucosal disease by sociodemographic characteristics among children with sickle cell disease recruited in SCD clinics in Kisumu from February 2025 to March 2025 (N=355)

Attribute	Group	Dental caries prevalence (%)	Plaque severity (%) moderate-severe (scores 2 and 3)	Mucosal disease prevalence (%)	Statistical test (χ^2, df, p-value)
Age (years)	10	33.3	-	12.5	Caries: $\chi^2(8)=31.761$, $p<0.001$; mucosal: $\chi^2(8)=9.812$, $p=0.278$
	11	57.7	-	19.2	
	12	37.0	-	15.0	
	13	12.8	-	23.4	
	14	48.6	-	10.8	
	15	41.7	-	8.3	
	16	31.3	-	31.2	
	17	62.5	-	18.8	
	18	61.0	-	7.3	
Gender	Male	43.5	66.0 (45.7 + 20.3)	15.9	Caries: $\chi^2(1)=1.142$, $p=0.286$; plaque: $\chi^2(3)=3.432$, $p=0.329$; mucosal: $\chi^2(1)=0.024$, $p=0.877$
	Female	37.8	70.5 (49.3 + 21.2)	14.7	
Education level	Primary	35.2	69.0 (47.8 + 21.1)	16.2	Caries: $\chi^2(1)=7.723$, $p=0.005$; plaque: $\chi^2(3)=1.623$, $p=0.654$; mucosal: $\chi^2(1)=0.384$, $p=0.536$
	Secondary	50.9	68.5 (48.1 + 20.4)	13.0	

Table 4: plaque score distribution, determinants, and dental caries prevalence with associated regression analyses among adolescents with sickle cell disease in Kisumu County collected between February 2025 to March 2025 (N=355)

Domain/predictor	Key statistics/model fit	Effect size (β)	Direction of association	Significance (p-value)	Interpretation/notes
Plaque severity distribution	Moderate: 47.9% (n=170), mild: 29.3% (n=104), severe: 20.8% (n=74), no plaque: 2.0% (n=7)	-	-	-	68.7% had moderate to severe plaque, indicating poor hygiene
Demographic predictors	R^2 = 0.062, adjusted R^2 = 0.051	Socioeconomic status: 0.244	Positive (higher SES → higher plaque)	<.001	SES significant; age, gender, and education not significant
		Age: -0.033	No significant effect	0.721	
		Gender: 0.019	No significant effect	0.710	
		Education level: 0.029	No significant effect	0.752	
Oral hygiene behaviors	R^2 = 0.202, adjusted R^2 = 0.186	Brushing frequency: -0.191	Negative (more brushing → less plaque)	<.001	Frequent brushing and fluoride use reduce plaque
		Use fluoride toothpaste: -0.171	Negative	0.001	
		Professional dental cleaning: 0.277	Positive (likely reactive)	<.001	Higher plaque despite cleaning suggests treatment after plaque buildup
		Recent dental visits: 0.167	Positive (likely reactive)	0.007	
		Brushing duration: 0.009	No significant effect	0.876	
		Flossing regularity: 0.061	No significant effect	0.207	

Table 5: regression analysis on determinants of oral health among adolescents with sickle cell disease in Kisumu County, collected between February 2025 to March 2025 (N=355)					
Domain/predictor	**Key statistics/model fit**	**Effect size (β)**	**Direction of association**	**Significance (p-value)**	**Interpretation/notes**
Dietary habits	R^2 = 0.001, adjusted R^2 = -0.004	Sugary foods: 0.019	No significant effect	0.717	Sugary/acidic food frequency is not associated with plaque
		Acidic foods: 0.031	No significant effect	0.565	
Psychosocial indicators	R^2 = 0.082, adjusted R^2 = 0.069	Impact on daily activities: 0.304	Positive	0.001	Higher impact corresponds to higher plaque
		Embarrassment in social situations: 0.254	Positive	<0.001	
		Stress or anxiety: 0.190	Positive	0.022	
		Avoiding smiling: 0.097	No significant effect	0.157	
		Sleep interference: 0.038	No significant effect	0.580	
Dental care access factors	R^2 = 0.116, adjusted R^2 = 0.100	Perception of care quality: -0.107	Negative	0.039	Positive perception reduces plaque
		Hindering factors: 0.150	Positive	0.033	Hindering factors increase plaque
		Barriers to access: -0.200	Negative	<0.001	Barriers increase plaque scores
		Attitude toward dental care: -0.035	No significant effect	0.497	
		Motivating factors: -0.022	No significant effect	0.669	
		Access to dental facilities: 0.015	No significant effect	0.820	