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Association of Gingival Melanin Pigmentation with Age, Sex, and Facial Skin Color among Primary Schoolchildren in Al-Najaf City, Iraq: A Cross-Sectional Study

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Abstract

Background: Physiologic gingival melanin pigmentation is common, yet little is known about its correlates among Iraqi schoolchildren. **Objective:** To estimate the prevalence of gingival melanin pigmentation among primary schoolchildren in Al-Najaf City, Iraq, and its association with age, sex, and facial skin color. **Materials and Methods:** In this cross-sectional study, 1522 children aged 7–11 years (770 boys, 752 girls) from six randomly selected schools were examined. A single examiner scored pigmentation with the Gingival Pigmentation Index and classified facial skin color visually as white, brown, or dark. Data were analyzed with chi-square or exact tests, crude odds ratios (ORs) with 95% confidence intervals (CIs), and logistic regression. **Results:** Gingival pigmentation was found in 460 children (30.2%; 95% CI 27.9–32.5) and showed no relation to age ($p = 0.517$). Girls were affected more often than boys (33.0% vs 27.5%; age-adjusted OR 1.31, 95% CI 1.05–1.63; $p = 0.018$). Prevalence was 0.6% among white-skinned, 62.8% among brown-skinned, and 37.5% among dark-skinned children ($p < 0.001$); compared with white skin, crude ORs were 263.8 (95% CI 108.0–643.9) for brown and 93.6 (95% CI 30.1–290.9) for dark skin. Most pigmented children (94.3%) had brown-to-black spots, and the pattern varied with skin color ($p < 0.001$) but not with sex ($p = 0.545$). **Conclusion:** Roughly one-third of the children had gingival pigmentation, which was closely tied to facial skin color, modestly higher in girls, and unrelated to age.

Keywords: gingival pigmentation; melanin; facial skin color; schoolchildren; sex; age.

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1. Introduction

The color of the gingiva is shaped by vascularity, epithelial thickness, the degree of keratinization, and the pigments within the epithelium, among which melanin contributes most often [1]. Melanin is synthesized by melanocytes located in the basal layer of the gingival epithelium [2,3]. Physiologic melanin pigmentation is found in all ethnic groups, although its extent differs between populations [3–5]. It is harmless, yet pronounced pigmentation can be an esthetic concern [6], and clinicians must distinguish it from pigmentation arising from local or systemic disease, such as that linked to iron overload in patients with thalassemia [1,7,8]. Systemic variables may also alter its appearance; for example, an inverse association has been found between blood hemoglobin levels and melanin pigmentation scores [9].

Among the external variables, tobacco smoke is the most extensively substantiated. A strong correlation has been shown between active smoking and gingival melanin pigmentation in adults [10], and pigmentation in young adults has been linked to exposure to environmental tobacco smoke [11], as well as in pediatric and adolescent populations [12-15]. The prevalence rates differ markedly among ethnic groups, ranging from 15% in Europeans to 89% in Indians [13]. In pediatric samples, pigmentation was observed in 82% of children aged 8 to 14 years [14], and in all preschool-aged children between 3 and 6 years [16].

Regarding skin color, age, and sex, the findings remain inconclusive. With advancing age, the intensity of pigmentation increased among participants aged 0–20 years [17] as well as in preschool-aged children [16]. Among children across primary, mixed, and permanent dentition stages, the link between age and gingival pigmentation was reported as weakly positive [18]. In contrast, no effect of age was observed in children aged 1–12 years [19]. Reports indicate that pigmentation levels peaked in adult smokers in their fourth decade of life, then declined, with former smokers showing less pigmentation than current smokers [20].

Findings on sex are similarly mixed: several studies found no difference [5,19,21], one pre-school study reported more pigmentation in boys [16], and a study of young adults found darker gingiva in women [22]. Most studies, in both children and adults, have described a relationship between facial skin color and gingival pigmentation [16,18,21–23]. Direct comparison of these results is difficult, however, because the studies differ in population, age range, setting, and assessment method.

In Iraq, published data on gingival pigmentation and skin color come largely from adults; in Kurdish adults in Sulaimani, for example, skin color correlated significantly with pigmentation intensity [24]. To our knowledge, gingival melanin pigmentation and its correlates have not yet been described in primary schoolchildren in central or southern Iraq. Such local data would help clinicians recognize physiologic pigmentation in children and would offer a baseline for future research.

Accordingly, the aims of this study were to (1) estimate the prevalence of gingival melanin pigmentation among primary schoolchildren aged 7–11 years in Al-Najaf City; (2) examine its association with age, sex, and facial skin color; and (3) compare the distribution of pigmentation patterns according to sex and facial skin color.

2. Materials and Methods

2.1 Study Design and Setting

This cross-sectional study was conducted among primary schoolchildren in Al-Najaf City, Iraq. Data were collected from October 2024 to February 2025. The report follows the STROBE recommendations for cross-sectional studies [25].

2.2 Study Population and Sampling

Sampling of schools. A stratified random sampling approach was used. Public primary schools in Al-Najaf City were grouped by geographic area, and

schools were randomly selected from these areas, yielding six schools in total, so that children from different parts of the city would be represented. Within each selected school, all eligible children aged 7–11 years were invited to participate; no further sampling of individual children was performed.

Eligibility criteria. Children were eligible if they (1) were enrolled in one of the six selected schools, (2) were aged 7–11 years, (3) were present at school on the examination day, and (4) had consent from a parent or guardian. Exclusion criteria were (1) a systemic disease or the use of medications known to be associated with oral or gingival pigmentation, according to school health records; (2) fixed orthodontic appliances, which obscure a clear view of the gingiva; and (3) parental refusal, absence on the examination day, or lack of cooperation with the examination. In total, 1522 children (770 boys and 752 girls) were examined.

Sample size. No a priori sample size calculation was performed; instead, all eligible children in the six schools were examined. With 1522 children, the overall prevalence of gingival pigmentation (30.2%) could be estimated with a precision of approximately ±2.3 percentage points (95% CI 27.9–32.5%).

2.3 Clinical Examination

Examinations took place at school using disposable mouth mirrors and tweezers, with cotton, gloves, and face masks. Sex, age, facial skin color, and gingival pigmentation were recorded on a standardized form. A single examiner performed all examinations, which eliminated variation between examiners.

2.4 Assessment of Facial Skin Color

Facial skin tone was assessed visually under natural daylight, which was recommended by Wright as the most reliable reference for judging the color [26], and each child was classified into one of three categories: white, brown, or dark.

2.5 Assessment of Gingival Melanin Pigmentation

Pigmentation levels were evaluated using the Gingival Pigmentation Index [27,28]:

- Score 0: absence of pigmentation;
- Score 1: brown-to-black spots;
- Score 2: brown-to-black patches without diffuse pigmentation;
- Score 3: diffuse brown-to-black pigmentation involving the marginal and attached gingiva.

Participants scoring 1 or above were categorized as exhibiting pigmentation and subsequently classified according to its distribution pattern (spots, patches, or diffuse). The index classifications served as pigmentation patterns, while severity was excluded as an independent outcome.

2.6 Ethical Considerations

Prior to data collection, parents were informed of the study and gave their consent; participation was optional. Participating schools granted permission for the examinations, which were visual and noninvasive. The study was conducted in accordance with the ethical guidelines of the Declaration of Helsinki.

2.7 Statistical Analysis

Data were analyzed using SPSS version 26 (IBM Corporation, Armonk, NY, USA). Categorical variables are presented as frequencies and percentages, with 95% confidence intervals for percentages calculated using the Wald method. Sample characteristics are described without statistical significance testing. Associations with pigmentation were tested using Pearson's chi-squared test or the Fisher-Freeman-Halton exact test when expected numbers were less than 5. Crude odds ratios were calculated using the Woolf method, and dark and brown skin tones were compared using Fisher's exact test. A binary logistic regression model was used to model pigmentation (present/absent) based on age and sex, with age included as a categorical variable and, in the

sensitivity analysis, for each year. Likelihood ratio tests assessed the overall effect of age and the interaction between age and sex. All tests were two-sided, with statistical significance set at $p < 0.05$.

3. Results

3.1 Characteristics of the Participants

A total of 1522 children took part: 770 boys (50.6%) and 752 girls (49.4%). Their ages ranged from 7 to 11 years, with 8-year-olds forming the largest group (n = 452, 29.7%) and 9-year-olds the smallest (n = 186, 12.2%). The age distribution differed between boys and girls: 7-year-olds made up 23.0% of girls but 16.4% of boys, whereas 11-year-olds made up 12.0% of girls and 19.5% of boys (Table 1). Age was therefore adjusted for when the sexes were compared (Section 3.4). Facial skin color was distributed similarly in boys and girls. Overall, 785 children (51.6%) had white, 705 (46.3%) brown, and 32 (2.1%) dark facial skin (Table 1).

3.2 Prevalence of Gingival Melanin Pigmentation

Gingival melanin pigmentation was observed in 460 of the 1522 children (30.2%; 95% CI 27.9–32.5), while 1062 (69.8%) showed none. Prevalence was 27.5% among boys (212/770; 95% CI 24.4–30.7) and 33.0% among girls (248/752; 95% CI 29.6–36.3).

3.3 Association with Age

Prevalence varied little across age groups: 30.1% at 7 years, 33.2% at 8, 28.0% at 9, 29.6% at 10, and 27.5% at 11 years ($\chi^2 = 3.25$, df = 4, $p = 0.517$). In logistic regression, the crude OR per year of age was 0.96 (95% CI 0.88–1.03; $p = 0.259$), and adjustment for sex left it at 0.96 (95% CI 0.89–1.04). With age treated as a categorical variable, the sex-adjusted likelihood-ratio test was likewise non-significant ($p = 0.476$) (Table 2).

3.4 Association with Sex

Girls were more often pigmented than boys (33.0% vs 27.5%; $\chi^2 = 5.35$, df = 1, $p = 0.021$). The crude OR for girls relative to boys was 1.30 (95% CI 1.04–1.61), and adjustment for age changed it little (OR 1.31, 95% CI 1.05–1.63; $p = 0.018$). Exploratory age-stratified comparisons showed that this difference was not uniform: it was larger at 7 years (36.4% vs 21.4%) and 10 years (34.9% vs 24.1%), absent at 8 years (33.3% vs 33.1%), and reversed at 11 years (24.4% vs 29.3%). The age-by-sex interaction, however, did not reach significance ($p = 0.061$) (Table 2).

3.5 Association with Facial Skin Color

Facial skin color showed the strongest association with pigmentation. Prevalence was 0.6% in white-skinned (5/785), 62.8% in brown-skinned (443/705), and 37.5% in dark-skinned (12/32) children ($\chi^2 = 682.2$, df = 2, $p < 0.001$). Relative to white skin, the crude OR was 263.8 (95% CI 108.0–643.9) for brown and 93.6 (95% CI 30.1–290.9) for dark skin. When dark skin was compared with brown, the crude OR was 0.35 (95% CI 0.17–0.74; Fisher exact $p = 0.005$). These ORs are unadjusted, and the dark-skin group was small (n = 32) (Table 2).

3.6 Distribution of Pigmentation Patterns by Sex and Facial Skin Color

Of the 460 pigmented children, 434 (94.3%) had brown-to-black spots, 23 (5.0%) had patches, and 3 (0.7%) had diffuse pigmentation. Boys and girls showed a similar pattern distribution (Fisher–Freeman–Halton exact $p = 0.545$; Pearson χ^2 $p = 0.537$, with expected counts below 5 for diffuse pigmentation). In contrast, the distribution differed significantly by facial skin color (exact $p < 0.001$). Spots predominated among brown-skinned children (432/443, 97.5%), whereas all 12 pigmented dark-skinned children had patches, and of the 5 pigmented white-skinned children, 2 had spots and 3 had patches. Diffuse pigmentation was seen only in brown-skinned children (3/443, 0.7%) (Table 3).

Table 1. Demographic characteristics and facial skin color distribution of the study participants (N = 1522).

Characteristic	**Male (n = 770)**	**Female (n = 752)**	**Total (N = 1522)**
Sex, n (% of total)	770 (50.6)	752 (49.4)	1522 (100)
Age, years, n (% of column)			
7	126 (16.4)	173 (23.0)	299 (19.6)
8	248 (32.2)	204 (27.1)	452 (29.7)
9	76 (9.9)	110 (14.6)	186 (12.2)
10	170 (22.1)	175 (23.3)	345 (22.7)
11	150 (19.5)	90 (12.0)	240 (15.8)
Facial skin color, n (% of column)			
White	390 (50.6)	395 (52.5)	785 (51.6)
Brown	362 (47.0)	343 (45.6)	705 (46.3)
Dark	18 (2.3)	14 (1.9)	32 (2.1)

Percentages use the column total as the denominator (sex row: total N).

Table 2. Association of gingival melanin pigmentation with age, sex, and facial skin color.

Variable	**Category**	**Total n**	**Pigmented, n (%)[1]**	**Crude OR (95% CI)**	**Adjusted OR (95% CI)[2]**	**P (crude)**	**P (adj.)**
Age (years)	7	299	90 (30.1)	–	–	0.517[3]	0.476
	8	452	150 (33.2)	–	–		
	9	186	52 (28.0)	–	–		
	10	345	102 (29.6)	–	–		
	11	240	66 (27.5)	–	–		
	Per 1-year increase	1522	–	0.96 (0.88–1.03)	0.96 (0.89–1.04)	0.259	0.342
Sex	Male	770	212 (27.5)	1.00 (reference)	1.00 (reference)	0.021[3]	–
	Female	752	248 (33.0)	1.30 (1.04–1.61)	1.31 (1.05–1.63)		0.018
Facial skin color	White	785	5 (0.6)	1.00 (reference)	Not estimable	<0.001[3]	–
	Brown	705	443 (62.8)	263.8 (108.0–643.9)	Not estimable		
	Dark	32	12 (37.5)	93.6 (30.1–290.9)	Not estimable		
Total		**1522**	**460 (30.2)**				

[1]Row percentage (pigmented / total in the category). [2]Logistic regression: sex adjusted for age (categorical: 7, 8, 9, 10, 11 years); per-year age adjusted for sex; the adjusted P for age (categorical) is the likelihood-ratio test adjusted for sex (P = 0.476). With age entered per year, the adjusted OR for girls was 1.28 (95% CI 1.03–1.60; P = 0.026). [3]Pearson chi-square (age $\chi^2 = 3.25$, df = 4; sex $\chi^2 = 5.35$, df = 1; facial skin color $\chi^2 = 682.2$, df = 2). Additional comparison: dark vs brown, crude OR 0.35 (95% CI 0.17–0.74; Fisher exact P = 0.005). OR = odds ratio; CI = confidence interval.

Table 3. Distribution of gingival pigmentation patterns according to sex and facial skin color (pigmented children only, n = 460).

Group	Pigmented, n	Spots (score 1), n (%)	Patches (score 2), n (%)	Diffuse (score 3), n (%)	P[4]
Overall	460	434 (94.3)	23 (5.0)	3 (0.7)	–
Sex					0.545
Male	212	198 (93.4)	13 (6.1)	1 (0.5)	
Female	248	236 (95.2)	10 (4.0)	2 (0.8)	
Facial skin color					<0.001
White	5	2 (40.0)	3 (60.0)	0 (0.0)	
Brown	443	432 (97.5)	8 (1.8)	3 (0.7)	
Dark	12	0 (0.0)	12 (100.0)	0 (0.0)	

Percentages use the number of pigmented children in each row as the denominator. [4]Fisher–Freeman–Halton exact test (expected counts below 5 in several cells); the Pearson chi-square P for sex was 0.537. With all children in each skin color group as the denominator: spots 0.3% (white), 61.3% (brown), 0.0% (dark); patches 0.4%, 1.1%, 37.5%; diffuse 0.0%, 0.4%, 0.0%. Children without pigmentation (score 0): 1062.

4. Discussion

In this sample of 1522 schoolchildren aged 7–11 years in Al-Najaf City, about 30% had gingival melanin pigmentation. There is a strong correlation between pigmentation and skin tone; this was slightly more common in girls. In contrast, it was not related to age. Due to the cross-sectional design of the study, its results describe correlations rather than causes.

Prevalence. The prevalence we observed falls within the wide range reported across ethnic groups [13] but is lower than that of recent pediatric studies from South Asia, which reported 82% in children aged 8–14 years [14] and 100% in pre-school children [16]. It is also below the 74% found in a Saudi clinic-based sample of participants aged 10 years and older [21]. These studies differ from ours in ethnic composition, age range, setting (clinic or school), and the definition of pigmentation; some, for example, recorded any visible pigmentation, whereas we applied a defined index. Which of these differences explains the lower prevalence cannot be determined from our data.

Age. We found no association with age, in line with the findings of Packyanathan and Lavanya in children aged 1–12 years [19]. Other studies, by contrast, reported that pigmentation intensity increased with age [16,17] or found a weak positive correlation between age and attached gingival pigmentation in children [18]. Those studies, however, covered wider or different age ranges and measured intensity, by index grade or by colorimetry, rather than the presence or absence of pigmentation; in adults, age-related differences are further complicated by smoking [20]. The narrow age range of our sample may also have limited our ability to detect a trend.

Sex. Girls were somewhat more often affected than boys, and this difference persisted after adjustment for age, although the association was modest. Earlier findings are inconsistent: several studies found no sex difference [5,19,21], one pre-school study reported more pigmentation in boys [16], and a study of young Saudi adults found darker gingiva in women [22]. In our sample, the sex difference was not consistent across age groups in exploratory analyses. Facial skin color was distributed similarly in boys and girls, which makes confounding by skin color less likely, although it cannot be ruled out. The sex difference should therefore be confirmed in other samples, and our data do not allow any biological explanation to be tested.

Facial skin color. The strong association between facial skin color and gingival pigmentation agrees with studies in children [16,18] and in adolescents

and adults [21–23], including Iraqi adults [24]. The very large ORs largely reflect the near absence of pigmentation among white-skinned children, and their wide confidence intervals mean they should not be read as precise effect estimates. Nor was the association graded by skin darkness, since prevalence was lower in the dark group than in the brown group. Given the small size of the dark-skin group and the visual assessment of skin color, this finding may reflect chance or misclassification and warrants cautious interpretation. Our data show only that facial and gingival pigmentation tend to occur together; they do not explain why.

Pigmentation patterns. Brown-to-black spots were by far the most common pattern, whereas patches and diffuse pigmentation were uncommon. The pattern distribution was similar in boys and girls but varied with facial skin color; the numbers of pigmented white-skinned (n = 5) and dark-skinned (n = 12) children, however, were very small. These differences should not be taken as differences in severity. Standardized intraoral photographs, which have shown acceptable validity and reliability for scoring gingival melanin pigmentation [29], would allow future studies to assess severity.

Clinical relevance. Awareness that physiologic pigmentation is common in schoolchildren and closely related to skin color may help clinicians distinguish it from pathologic pigmentation and reassure families who view it as an esthetic concern [6,7]. Pigmentation also matters in periodontal examination, as it reduces the visibility of periodontal probes used to assess gingival thickness [30]. Because no predictive analysis was performed, however, these data do not support using facial skin color as a diagnostic or predictive tool.

5. Strengths and Limitations

Strengths: The key advantage of this study is its large sample size of 1,522 schoolchildren drawn from randomly selected primary schools. Using a defined Gingival Pigmentation Index ensured a consistent assessment of the prevalence and patterns of pigmentation, and because one examiner assessed all participants, variation between examiners did not influence the results.

Limitations: Due to the cross-sectional nature of the study, causal relationships cannot be established.

6. Conclusion

About 30% of the examined primary schoolchildren in Al-Najaf City exhibited gingival melanin pigmentation, mostly in the form of brown-to-black spots. Pigmentation was strongly associated with facial skin color, modestly associated with female sex, and independent of age. As these associations are cross-sectional, they do not establish causation, and the sex difference needs confirmation in other samples. Further studies using objective measurement of skin color and collecting information on exposures such as passive smoking are needed.

Ethics approval and consent to participate: Parents or legal guardians were informed about the purpose and procedures of the study, and their consent was obtained before data collection; the children's willingness to participate was respected. Formal review by an institutional ethics committee was not obtained before data collection.

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References

1. Peeran SW, Ramalingam K, Peeran SA, Altaher OB, Alsaid FM, Mugrabi MH. Gingival pigmentation index proposal of a new index with a brief review of current indices. Eur J Dent. 2014;8(2):287–90.

2. Patil KP, Joshi V, Waghmode V, Kanakdande V. Gingival depigmentation: a split mouth comparative study between scalpel and cryosurgery. Contemp Clin Dent. 2015;6(Suppl 1):S97–101.

3. Feller L, Masilana A, Khammissa RAG, Altini M, Jadwat Y, Lemmer J. Melanin: the biophysiology of oral melanocytes and physiological oral pigmentation. Head Face Med. 2014;10:8. doi:10.1186/1746-160X-10-8

4. Masilana A, Khammissa RAG, Lemmer J, Feller L. Physiological oral melanin pigmentation in a South African sample: a clinical study. J Investig Clin Dent. 2017;8(4):e12258. doi:10.1111/jicd.12258

5. Ho DK, Ghinea R, Herrera LJ, Angelov N, Paravina RD. Color range and color distribution of healthy human gingiva: a prospective clinical study. Sci Rep. 2015;5:18498. doi:10.1038/srep18498

6. Raj P, Nagesh S, Boyapati R. Impact of gingival pigmentation on laypersons' perception of smile aesthetics: an observational study. Explor Med. 2025;6:1001274. doi:10.37349/emed.2025.1001274

7. Alawi F. Pigmented lesions of the oral cavity: an update. Dent Clin North Am. 2013;57(4):699–710. doi:10.1016/j.cden.2013.07.006

8. Gajjar S, Kaur H, Girdhar G, Kaur A, Patel C, Mehta R, et al. Identifying gingival pigmentation patterns and skin color and its co-relation with serum ferritin levels in thalassemic patients. Cureus. 2022;14(8):e28015. doi:10.7759/cureus.28015

9. Daniel RA, Veena HR, Basavaraju S. Relationship of hemoglobin levels and distribution and severity of gingival melanin pigmentation: an exploratory cross-sectional study. J Adv Periodontol Implant Dent. 2024;16(2):103–8. doi:10.34172/japid.2024.020

10. Haresaku S, Hanioka T, Tsutsui A, Watanabe T. Association of lip pigmentation with smoking and gingival melanin pigmentation. Oral Dis. 2007;13(1):71–6. doi:10.1111/j.1601-0825.2006.01249.x

11. Ponnaiyan D, Chillara P, Palani Y. Correlation of environmental tobacco smoke to gingival pigmentation and salivary alpha amylase in young adults. Eur J Dent. 2017;11(3):364–9. doi:10.4103/ejd.ejd_99_17

12. Hanioka T, Tanaka K, Ojima M, Yuuki K. Association of melanin pigmentation in the gingiva of children with parents who smoke. Pediatrics. 2005;116(2):e186–90.

13. Hajifattahi F, Azarshab M, Haghgoo R, Lesan S. Evaluation of the relationship between passive smoking and oral pigmentation in children. J Dent (Tehran). 2010;7(3):119–23.

14. Anand A, Raja T, Thakur V, Agarwal N. Evaluation of the effect of parental smoking on gingival melanin pigmentation in children. Int J Clin Pediatr Dent. 2024;17(2):173–5. doi:10.5005/jp-journals-10005-2773

15. Sridharan S, Ganiger K, Satyanarayana A, Rahul A, Shetty S. Effect of environmental tobacco smoke from smoker parents on gingival pigmentation in children and young adults: a cross-sectional study. J Periodontol. 2011;82(7):956–62. doi:10.1902/jop.2010.100479

16. Verma J, Ahuja A, Ahuja V, Thosar NR. Reconnoitering the association of gingival melanin pigmentation with skin color, age, and sex in pre-school children of Hazaribag: a cross-sectional study. Cureus. 2022;14(10):e30699. doi:10.7759/cureus.30699

17. Janiani P, Bhat PR, Trasad VA, Acharya AB, Thakur SL. Evaluation of the intensity of gingival melanin pigmentation at different age groups in the Indian population: an observational study. J Indian Soc Pedod Prev Dent. 2018;36(4):329–33.

18. Bane PV, Deshpande AN, Dave BH, Bargale SS, Poonacha KS, Kariya PB. Correlation of facial skin colour and melanin pigmentation in the gingiva of children in primary, mixed and permanent dentition: an observational study. Adv Hum Biol. 2025;15(1):66–72. doi:10.4103/aihb.aihb_34_23

19. Packyanathan JS, Lavanya G. Evaluation of gingival melanin pigmentation in pediatric population: an observational study. J Family Med Prim Care. 2019;8(8):2623–7. doi:10.4103/jfmpc.jfmpc_332_19

20. Kato T, Mizutani S, Takiuchi H, Sugiyama S, Hanioka T, Naito T. Gingival pigmentation affected by smoking among different age groups: a quantitative analysis of gingival pigmentation using clinical oral photographs. Int J Environ Res Public Health. 2017;14(8):880. doi:10.3390/ijerph14080880

21. Mirdad A, Alqarni M, Bukhari A, Alaqeely R. Gingival pigmentation features in correlation with tooth and skin shades: a cross-sectional study in a Saudi population. Oral Health Prev Dent. 2023;21:b4347777. doi:10.3290/j.ohpd.b4347777

22. Koppolu P, Almutairi H, Al Yousef S, Ansary N, Noushad M, Vishal MB, et al. Relationship of skin complexion with gingival tissue color and hyperpigmentation: a multi-ethnic comparative study. BMC Oral Health. 2024;24:451. doi:10.1186/s12903-024-04189-7

23. Ponnaiyan D, Jegadeesan V, Perumal G, Anusha A. Correlating skin color with gingival pigmentation patterns in South Indians – a cross sectional study. Oral Health Dent Manag. 2014;13(1):132–6.

24. Amin S, Azeez SH. Gingival pigmentation pattern in correlation to skin color in a group of Kurdish people in Sulaimani City. Al-Kindy Coll Med J. 2022;18(3):237–42. doi:10.47723/kcmj.v18i3.874

25. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet. 2007;370(9596):1453–7. doi:10.1016/S0140-6736(07)61602-X

26. Wright SM. Prosthetic reproduction of gingival pigmentation. Br Dent J. 1974;136(9):367–72. doi:10.1038/sj.bdj.4803188

27. Singh V, Giliyar SB, Kumar S, Bhat M. Comparative evaluation of gingival depigmentation by diode laser and cryosurgery using tetrafluoroethane: 18-month follow-up. Clin Adv Periodontics. 2012;2(3):129–34. doi:10.1902/cap.2012.110008

28. Kumar S, Bhat GS, Bhat KM. Comparative evaluation of gingival depigmentation using tetrafluoroethane cryosurgery and gingival abrasion technique: two years follow up. J Clin Diagn Res. 2013;7(2):389–94. doi:10.7860/JCDR/2013/4454.2779

29. Zahid TM, Natto ZS. Validity and reliability of polarized vs non-polarized digital images for measuring gingival melanin pigmentation. Clin Cosmet Investig Dent. 2023;15:189–97. doi:10.2147/CCIDE.S422139

30. Nik-Azis NM, Razali M, Goh V, Ahmad Shuhaimi NN, Mohd Nazrin NAS. Assessment of gingival thickness in multi-ethnic subjects with different gingival pigmentation levels. J Clin Periodontol. 2023;50(1):80–9. doi:10.1111/jcpe.13723