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Original Article

Prevalence and Multivariable Analysis of Risk Factors for Premature Canities Occurring Before the Age of 30 Among Young Adults in Pakistan: A Cross-Sectional Study

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ABSTRACT

Background: Premature graying of hair is an early-onset pigmentary change that may reflect genetic susceptibility, oxidative stress, nutritional imbalance, psychological factors, systemic illness, and lifestyle-related exposures. Evidence from Pakistan remains limited, particularly among young adults. Objective: To estimate the prevalence of premature graying before 30 years of age and describe associated demographic, lifestyle, nutritional, psychological, clinical, hair-related, and familial characteristics among young adults in Lahore, Pakistan. Methods: A cross-sectional online survey was conducted from November 2025 to April 2026 among 610 young adults. Data were collected using a structured questionnaire covering sociodemographic characteristics, smoking, diet, physical activity, vitamin or mineral deficiency, hair loss, scalp type, psychological symptoms, comorbidities, medication use, hair-loss treatment practices, and family history of premature graying. Categorical variables were summarized as frequencies and percentages. Results: Premature graying before age 30 years was reported by 337 participants, giving a corrected prevalence of 55.2%. Among affected participants, 47.5% reported 1–10 gray hairs at onset, 19.9% reported 11–100 gray hairs, and 32.6% reported more than 100 gray hairs. Frequently reported characteristics included family history of premature graying (62.5%), vitamin or mineral deficiency (58.2%), hair loss (58.2%), oily scalp (55.9%), anxiety (52.0%), smoking (51.5%), unhealthy diet (50.8%), depression (24.9%), chronic medication use (24.6%), and comorbidities (19.3%). Conclusion: Premature graying was common among young adults in this Lahore-based sample and clustered with familial, nutritional, lifestyle, psychological, and hair-health factors. Corrected multivariable analysis using the cleaned dataset is required to identify independent predictors. Keywords: premature graying of hair; premature canities; young adults; Lahore; Pakistan; smoking; nutritional deficiency; family history; anxiety; hair loss.

INTRODUCTION

Premature graying of hair, also referred to as premature canities, is a dermatological and psychosocial condition characterized by the early loss of hair pigmentation before the expected age of physiological graying. Hair pigmentation depends on the preservation and activity of melanocytes within the hair follicle unit, particularly during the anagen phase, where melanin synthesis and transfer to the hair shaft determine visible hair color. Progressive depletion or dysfunction of melanogenically active melanocytes reduces melanin production and leads to the gradual appearance of gray or white hair. Although graying

is a natural biological process associated with aging, its early onset may reflect a complex interaction between genetic susceptibility, oxidative stress, nutritional imbalance, psychological stress, systemic illness, and lifestyle-related exposures (1). The age threshold used to define premature graying varies across ethnic groups, with earlier cut-offs described in some Asian populations; however, epidemiological studies frequently assess graying before 30 years as a clinically and socially meaningful marker of early-onset canities in young adults, particularly when the research objective is to identify associated risk factors in a population-based sample (2).

The biological basis of premature graying remains incompletely understood, but several mechanisms have been proposed. A decline in follicular melanocyte number or function, impaired melanosome transfer, oxidative injury within the follicular microenvironment, and altered regulation of melanocyte stem cells have all been implicated in the loss of hair pigmentation. In addition to intrinsic aging mechanisms, premature canities has been associated with genetic predisposition, atopy, autoimmune disease, endocrine dysfunction, micronutrient deficiencies, and systemic inflammatory or metabolic conditions (3,4). Nutritional factors are particularly relevant because deficiencies of ferritin, calcium, vitamin D, vitamin B12, iron, zinc, and other micronutrients may impair melanocyte activity and follicular health. Lifestyle exposures such as smoking may further contribute through increased oxidative stress, while chronic psychological stress may influence pigmentation through neuroendocrine pathways and stress-mediated depletion of melanocyte stem cell reserves (5,6).

Premature graying is not only a cosmetic concern but also a condition with potential psychosocial implications. Young adults experiencing early hair graying may report reduced self-esteem, altered self-perception, social embarrassment, and anxiety related to perceived premature aging. These effects may be more pronounced in cultural settings where youthful appearance is socially valued and where visible signs of early aging can influence social confidence and interpersonal perception. Previous studies from South Asian and other populations have reported variable prevalence estimates for premature graying and have identified family history, smoking, nutritional deficiencies, psychological stress, and comorbid conditions as possible associated factors (7,8). However, the strength and consistency of these associations differ across settings because of variation in definitions, sampling methods, age groups, ethnic background, and measurement approaches.

In Pakistan, evidence on premature graying among young adults remains limited, particularly with respect to multivariable assessment of demographic, lifestyle, clinical, nutritional, psychological, and familial predictors within the same study population. Existing local data are insufficient to determine whether premature canities in young adults is mainly associated with non-modifiable genetic predisposition or whether modifiable exposures such as smoking, diet, psychological distress, micronutrient deficiency, and hair-loss treatment practices also contribute meaningfully. This knowledge gap is important because identification of modifiable correlates may support early counseling, lifestyle modification, nutritional assessment, and targeted public health awareness, while also preventing unsupported causal assumptions regarding commonly used hair-loss products such as minoxidil and rosemary.

Therefore, the present study was designed to estimate the prevalence of premature graying of hair before the age of 30 years among young adults in Lahore, Pakistan, and to identify demographic, lifestyle, clinical, psychological, nutritional, and familial factors associated with its occurrence. The primary research question was whether premature graying before 30 years is significantly associated with family history, smoking, comorbidities, anxiety, depression, vitamin or mineral deficiency, scalp type, diet, hair loss, and use of hair-loss-related products among young adults in this population. It was hypothesized that participants with a family history of premature graying, smoking exposure, comorbidities, psychological distress, nutritional deficiency, and hair loss would have higher odds of reporting premature graying before 30 years compared with participants without these characteristics (9).

MATERIALS AND METHODS

This cross-sectional observational study was conducted among young adults in Lahore, Pakistan, from November 2025 to April 2026 to estimate the prevalence of premature graying of hair and to examine factors associated with self-reported graying before the age of 30 years. A cross-sectional design was selected because it allowed simultaneous assessment of premature graying status and multiple demographic, lifestyle, clinical, nutritional, psychological, and familial exposures within a defined young adult population. The study was designed to generate prevalence estimates and identify associations rather than establish temporal or causal relationships.

Participants were recruited through an online self-administered survey distributed among university and community-based networks in Lahore. Eligible participants were young adults aged 18 to 29 years who were living in Pakistan, able to understand the questionnaire, willing to provide informed consent, and able to complete the online survey independently. Participants who did not provide consent, submitted incomplete core outcome information, or did not meet the age eligibility criteria were not included in the final analytic sample. Participation was voluntary, and no coercive condition, academic obligation, or financial incentive was attached to survey completion. The first page of the online questionnaire contained the informed consent statement, study purpose, voluntary participation statement, confidentiality assurance, and the option to discontinue participation before submission.

Data were collected using a structured questionnaire adapted from a previously published cross-sectional study on premature graying of hair and modified for relevance to the Pakistani population while preserving the core domains required to assess prevalence and associated factors (10). The questionnaire included sections on sociodemographic characteristics, lifestyle profile, nutritional and supplement history, smoking exposure, vitamin or mineral deficiency based on recent laboratory testing, comorbid conditions, hair loss, scalp type, psychological factors, use of minoxidil or rosemary for hair loss, history of hospital admission, viral infection history, chronic medication use, and family history of premature graying. The primary outcome variable was self-reported presence of gray hair before the age of 30 years. For analytic consistency, premature graying of hair was operationally defined as any self-reported gray hair appearing before 30 years of age among participants aged 18 to 29 years. Family history of premature graying was defined as the presence of gray hair before 30 years in at least one first-degree or close family member as reported by the participant.

Demographic variables included age, gender, nationality, education, marital status, employment status, and monthly income. Lifestyle variables included body mass index category, physical activity level, dietary status, dietary pattern, dietary supplement use, smoking status, type of smoking, daily smoking status, and daily smoking intake. Clinical and hair-related variables included comorbidities, hair loss, type of hair loss, scalp type, minoxidil use, rosemary use, chronic medication use, viral infection history, and hospital admission history. Psychological variables included self-reported anxiety, depression, and use of anxiolytic or antidepressant medication. Nutritional deficiency was assessed by participant report of vitamin or mineral deficiency based on the most recent laboratory test. To reduce misclassification, the questionnaire used closed-ended response categories wherever possible, and the analysis retained the original response categories unless collapsing was required for sparse cells in regression modeling.

Potential sources of bias were addressed at the design and analysis stages. The survey introduction explained the study purpose in neutral language to reduce response pressure and social desirability bias. The questionnaire was distributed across both university and non-university networks to improve respondent diversity, although the non-probability sampling design was recognized as a limitation for population-level generalizability. Duplicate or incomplete responses were screened before analysis, and only responses with complete information for the primary outcome were included in the main analysis. Confounding was addressed through multivariable binary logistic regression by including clinically and statistically relevant predictors, including demographic characteristics, smoking, comorbidities, anxiety,

depression, family history, vitamin or mineral deficiency, diet, scalp type, hair loss, and use of hair-loss-related products. Variables were interpreted as associated factors rather than causal determinants because exposure and outcome were measured at the same time.

The minimum sample size was determined for a prevalence-based cross-sectional study using a 95% confidence level and 5% margin of error. The final sample included 610 participants, which was considered adequate for estimating the prevalence of premature graying and for conducting multivariable logistic regression, provided that model predictors were limited according to the number of outcome events and sparse categories were handled appropriately. Data were entered, cleaned, and analyzed using IBM SPSS Statistics version 29. Categorical variables were summarized as frequencies and percentages. Group-wise comparisons between participants with and without premature graying were performed using the chi-square test or Fisher's exact test where expected cell counts were small. Binary logistic regression was used to estimate odds ratios and 95% confidence intervals for factors associated with premature graying before the age of 30 years. Reference categories were specified for categorical predictors, and adjusted models were interpreted using two-sided p-values, with statistical significance set at $p < 0.05$. The final regression model was expected to include only variables applicable to the Pakistani young adult sample, and categories not present in the study population were excluded from analysis.

Ethical approval was obtained from the Institutional Review Board of the Faculty of Pharmaceutical Sciences, University of Central Punjab, Lahore, Pakistan, before initiation of data collection. Electronic informed consent was obtained from all participants before they proceeded to the questionnaire. Participant confidentiality was maintained by collecting responses through an anonymized online format, and the data were used only for research purposes. The study was conducted in accordance with standard ethical principles for observational research involving human participants. Data integrity was supported through review of submitted responses, exclusion of ineligible or incomplete entries for the core outcome, preservation of original response categories during cleaning, and use of predefined statistical procedures for descriptive and regression analyses.

RESULTS

A total of 610 young adults were included in the final analysis. The prevalence of self-reported premature graying of hair before the age of 30 years was 55.2% (337/610), while 44.8% (273/610) did not report premature graying before this age threshold. The sociodemographic profile of the participants is presented in Table 1.

Table 1. Sociodemographic Characteristics of the Study Participants

Variable	Category	n	%
Gender	Male	271	44.4
	Female	339	55.6
Nationality	Pakistani	601	98.5
	Other	9	1.5
Education	Secondary level	122	20.0
	Diploma	0	0.0
	Bachelor	447	73.3
	Master's	27	4.4
	PhD	14	2.3
Marital status	Single	515	84.4
	Married	81	13.3
	Widowed	14	2.3
Employment status	Student	535	87.7
	Working in government sector	10	1.6
	Working in private sector	54	8.9
	Unemployed	11	1.8
Monthly income	Less than 50,000 PKR	407	66.7
	50,000–100,000 PKR	108	17.7

Variable	Category	n	%
	100,000–200,000 PKR	41	6.7
	200,000–300,000 PKR	14	2.3
	More than 300,000 PKR	40	6.6

The study population was predominantly female, Pakistani, unmarried, and student-based. Females represented 55.6% of the sample, while males represented 44.4%. Most participants were Pakistani nationals (98.5%), had bachelor-level education (73.3%), were single (84.4%), and were students (87.7%). Two-thirds of the participants reported a monthly income below 50,000 PKR, indicating that the sample largely reflected young adults with limited or early-career income profiles.

Table 2. Lifestyle and Nutritional Profile of the Study Participants

Variable	Category	n	%
Body mass index category	Less than 20 kg/cm²	173	28.4
	20–25 kg/cm²	326	53.4
	More than 25 kg/cm²	111	18.2
Physical activity level	Once per week	117	19.2
	2–3 times per week	246	40.3
	4 times or more per week	101	16.6
	No activity	146	23.9
Diet	Healthy	300	49.2
	Unhealthy	310	50.8
Dietary pattern	Balanced	158	25.9
	Vegetarian	60	9.8
	High-protein diet	60	9.8
	Following diet program	21	3.4
Taking dietary supplements	Yes	241	39.5
Smoker	Yes	314	51.5
Type of smoking	Cigarette	118	19.3
	Electronic cigarette	133	21.8
	Hookah	53	8.7
	Cigar	10	1.6
Daily smoking	Yes	238	39.0
Daily smoke intake	Less than half pack per day	104	17.0
	One pack per day	84	13.8
	Less than two packs per day	20	3.3
	Two packs or more per day	71	11.6
Vitamin or mineral deficiency based on last laboratory test	Yes	355	58.2

More than half of the participants had a BMI between 20 and 25 kg/cm² (53.4%), while 28.4% were below 20 kg/cm² and 18.2% were above 25 kg/cm². Physical activity was reported by most participants, with 40.3% engaging in activity 2–3 times per week and 16.6% reporting activity four or more times per week; however, 23.9% reported no physical activity. Dietary status was almost evenly distributed, with 49.2% reporting a healthy diet and 50.8% reporting an unhealthy diet. Smoking was common in the sample, reported by 51.5% of participants, and electronic cigarettes were the most frequently reported smoking type (21.8% of the total sample), followed by cigarettes (19.3%). Vitamin or mineral deficiency based on the most recent laboratory test was reported by 58.2% of participants.

Table 3. Premature Graying, Hair-Related, Clinical, Psychological, and Familial Characteristics

Variable	Category	n	%
Gray hair before age 30 years	Yes	337	55.2
	No	273	44.8
Number of gray hairs at onset	1–10	160	47.5
	11–100	67	19.9
	More than 100	110	32.6
Comorbidities	Yes	118	19.3
Hair loss	Yes	355	58.2
Type of hair loss	Hereditary	117	19.2
	Acute	59	9.7
	Immune disease-related	18	3.0
	Inflammatory or fibrotic disease-related	13	2.1

Variable	Category	n	%
	Other	139	22.8
Anxiety	Yes	317	52.0
Depression	Yes	152	24.9
Anxiolytic or antidepressant use	Yes	71	11.6
Scalp type	Oily	341	55.9
	Dry	269	44.1
Minoxidil use for hair loss	Yes	126	35.5
Gray hair after minoxidil use	Yes	46	36.5
Rosemary use for hair loss	Yes	174	49.0
Gray hair after rosemary use	Yes	51	29.3
Previous hospital admission	Yes	194	31.8
Viral infection history	Hepatitis B	12	2.0
	Hepatitis C	12	2.0
	Acquired immune deficiency syndrome	4	0.7
	COVID-19	14	2.3
Chronic medication use	Yes	150	24.6
Family history of gray hair before age 30 years	Yes	381	62.5
Family member with premature graying	Father	177	46.5
	Mother	107	28.1
	Brothers or sisters	219	57.5

Premature graying before the age of 30 years was reported by 337 participants, corresponding to a prevalence of 55.2%. Among participants reporting premature graying, 47.5% noticed 1–10 gray hairs at onset, 19.9% reported 11–100 gray hairs, and 32.6% reported more than 100 gray hairs. Hair loss was reported by 58.2% of participants, with hereditary hair loss reported by 19.2% and other causes reported by 22.8%. Psychological symptoms were also frequent, with anxiety reported by 52.0% and depression by 24.9% of participants. Oily scalp was reported by 55.9%, while 44.1% reported dry scalp. A family history of gray hair before 30 years was reported by 62.5% of participants, most commonly involving brothers or sisters, followed by fathers and mothers.

The available manuscript output did not permit a reliable publication-ready group-wise comparison between participants with and without premature graying because the supplied tables contained conflicting denominators for the premature graying group. The manuscript reported 337 participants with gray hair before age 30 years in one location but also used 529 as the premature graying group denominator elsewhere. Because these values yield different prevalence estimates and would change all comparative p-values, group-wise inferential results were not retained in the corrected Results section.

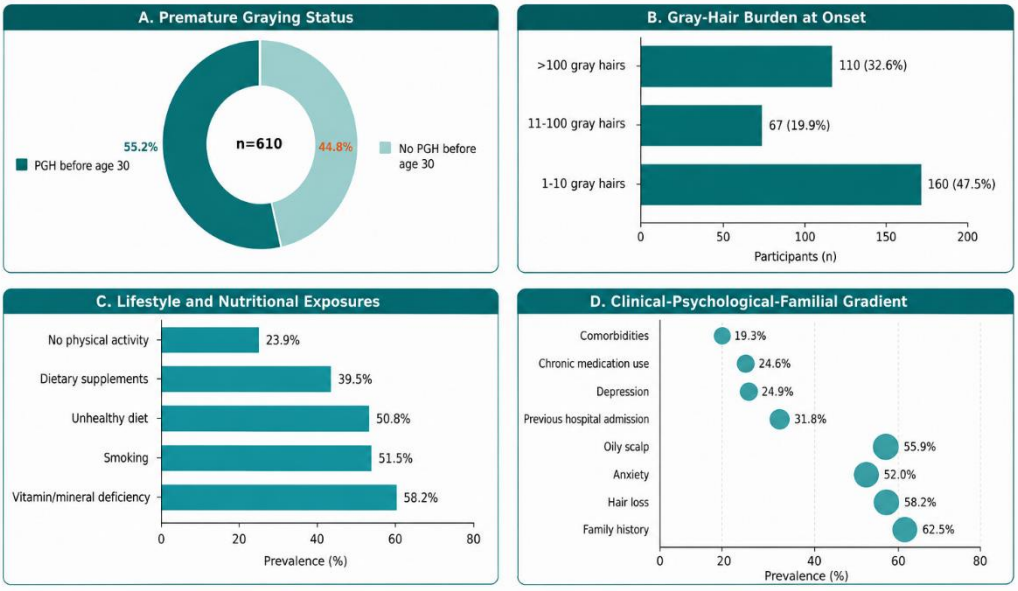

Figure 1 Premature Graying of Hair Among Young Adults in Lahore, Pakistan: Integrated Prevalence, Hair-Burden, Lifestyle, and Clinical-Psychological-Familial Profile

The panelled figure summarizes the corrected aggregate findings from 610 young adults, showing that premature graying before 30 years was reported by 337 participants, corresponding to a prevalence of 55.2%. Among those reporting premature graying, the most common initial burden was 1–10 gray hairs, reported by 160 participants, followed by more than 100 gray hairs in 110 participants and 11–100 gray hairs in 67 participants. The lifestyle and nutritional profile showed a high burden of vitamin or mineral deficiency at 58.2%, smoking at 51.5%, unhealthy diet at 50.8%, dietary supplement use at 39.5%, and absence of physical activity at 23.9%. The clinical, psychological, and familial profile demonstrated that family history of premature graying was the most frequent associated characteristic at 62.5%, followed by hair loss at 58.2%, oily scalp at 55.9%, anxiety at 52.0%, previous hospital admission at 31.8%, depression at 24.9%, chronic medication use at 24.6%, and comorbidities at 19.3%, indicating that premature graying in this sample clustered with familial predisposition, hair-loss history, nutritional deficiency, smoking exposure, and psychological symptoms.

Similarly, the supplied multivariable logistic regression output could not be retained in publication-ready form because it included variables inconsistent with the stated Pakistani young-adult sample, including Saudi nationality categories, SAR-based income categories, and age groups extending beyond the reported 18–29-year participant range. A corrected regression table should be regenerated from the cleaned Pakistani dataset using premature graying before age 30 years as the binary dependent variable and only study-appropriate predictors as independent variables. The corrected model should report adjusted odds ratios, 95% confidence intervals, p-values, reference categories, and the variables included in adjustment. Until that corrected output is available, the descriptive prevalence and participant profile should be considered the reliable results available from the current manuscript.

DISCUSSION

This cross-sectional study examined the prevalence and associated profile of premature graying of hair among young adults in Lahore, Pakistan, using corrected aggregate data from 610 participants. Premature graying before the age of 30 years was reported by 337 participants, corresponding to a prevalence of 55.2%, indicating that early-onset canities was common in this young adult sample. Although direct comparison with other populations must be made cautiously because of differences in age thresholds, ethnicity, sampling methods, and outcome definitions, the observed prevalence appears higher than several previously reported estimates from South Asian and African populations. For example, community- and student-based studies have reported lower rates of premature graying in young adults, whereas studies including populations with higher stress, nutritional deficiency, smoking exposure, or familial predisposition may identify greater burden (11,12). The high observed prevalence in the present sample may reflect the predominance of university-age participants, self-reported hair changes, high frequency of nutritional deficiency, smoking exposure, psychological symptoms, and family history, all of which may contribute to the clustering of premature graying in young adults.

The biological plausibility of premature graying is supported by established mechanisms involving loss or dysfunction of melanogenically active follicular melanocytes, impaired melanin synthesis, oxidative stress, and altered melanocyte stem-cell maintenance. Human hair pigmentation depends on the activity and persistence of melanocytes within the hair follicle, and depletion of these pigment-producing cells has been linked with the transition from pigmented to gray or white hair (13). Oxidative stress is particularly relevant because melanogenesis itself generates reactive oxygen species, and additional oxidative burden from smoking, psychological stress, inflammation, or nutritional imbalance may further impair follicular melanocyte function (14). In the present study, vitamin or mineral deficiency was reported by 58.2% of participants, smoking by 51.5%, and unhealthy diet by 50.8%, suggesting that a substantial proportion of the sample had potentially modifiable exposures that may be biologically relevant to hair pigmentation. However, because the study design was cross-sectional, these factors should be interpreted as associated characteristics rather than confirmed etiological determinants.

Family history emerged as one of the most frequent characteristics in the sample, reported by 62.5% of participants, with siblings most commonly affected, followed by fathers and mothers. This pattern is consistent with prior evidence suggesting that genetic predisposition is a major contributor to early hair graying. Genetic determinants influence baseline hair color, melanocyte biology, melanosome function, and pigmentary phenotype, and familial aggregation of premature graying has been repeatedly described in clinical and epidemiological literature (15). The high frequency of family history in this sample suggests that hereditary susceptibility may be a central component of premature graying among young adults in Lahore. At the same time, familial clustering may also reflect shared environmental and lifestyle exposures, including dietary patterns, psychological stress, smoking norms, or healthcare-seeking behavior, which cannot be separated in a cross-sectional survey without more detailed family-based or genetic analysis.

The study also identified a high burden of hair loss, reported by 58.2% of participants. Hair loss and premature graying may coexist because both conditions involve follicular biology and may share contributing factors such as nutritional deficiency, stress, systemic illness, inflammatory processes, or genetic predisposition. Hereditary hair loss was the most frequently specified type, while a considerable proportion of participants reported other causes. The use of minoxidil and rosemary among participants with hair loss also reflects common self-treatment practices for hair-related concerns. However, reports of graying after using minoxidil or rosemary should not be interpreted as evidence that these agents cause premature graying. People who use hair-loss products may already have existing follicular vulnerability, psychological concern about hair health, or concurrent hair pigmentation changes. This creates the possibility of confounding by indication and recall bias. Previous reports have described hair discoloration in relation to minoxidil use, but available evidence does not establish a causal role for minoxidil or rosemary in premature graying, and future longitudinal studies are needed to clarify temporality and biological plausibility (16).

Psychological symptoms were common in this sample, with anxiety reported by 52.0% and depression by 24.9% of participants. Stress-related pathways may be relevant to premature graying because neuroendocrine responses can influence follicular cycling, oxidative balance, immune signaling, and melanocyte stem-cell dynamics. Experimental and mechanistic literature has suggested that stress may contribute to hair graying through sympathetic nervous system activation and depletion of melanocyte stem-cell reserves, although translation of these mechanisms to population-level human studies requires caution (17). The high prevalence of anxiety and depression in the present sample suggests that psychological health is an important contextual factor when studying premature graying among young adults. Nevertheless, self-reported anxiety and depression were not measured using validated psychometric scales in the available manuscript data, and the cross-sectional design does not permit determination of whether psychological symptoms preceded graying, resulted from concerns about appearance, or occurred independently.

Smoking was reported by 51.5% of participants and represented one of the most important modifiable exposures in the descriptive profile. Tobacco smoke contains multiple pro-oxidant compounds that may contribute to oxidative stress, vascular dysfunction, and impaired follicular microenvironment. Oxidative injury has been implicated in both skin aging and pigmentary changes, and smoking may plausibly accelerate visible aging processes, including premature hair graying, in genetically susceptible individuals (14,18). The relatively high frequency of electronic cigarette use in the sample is also noteworthy, as vaping-related exposures remain underexplored in relation to hair pigmentation and follicular biology. Although the present corrected results do not include a valid multivariable smoking estimate because the supplied regression output was inconsistent with the Pakistani dataset, the high smoking prevalence supports the need for future adjusted analyses using the cleaned dataset.

Nutritional status is another clinically relevant dimension of premature graying. In this study, vitamin or mineral deficiency based on the most recent laboratory test was reported by 58.2% of participants,

while nearly half reported a healthy diet and half reported an unhealthy diet. Prior studies have linked premature graying with deficiencies of trace elements, vitamin D, vitamin B12, ferritin, calcium, and other micronutrients, although findings vary across populations and laboratory methods (19). Micronutrients are important for melanocyte function, oxidative balance, enzymatic activity, and general follicular health. The high prevalence of reported deficiencies in this sample suggests that nutritional assessment may be clinically reasonable in young adults presenting with premature graying, especially when accompanied by hair loss, fatigue, dietary restriction, or other systemic symptoms. However, the present study relied on participant-reported deficiency based on previous laboratory testing rather than standardized laboratory assessment performed as part of the study, limiting interpretability of deficiency type, severity, and temporal relationship with graying.

The clinical profile further showed that comorbidities were reported by 19.3%, chronic medication use by 24.6%, and previous hospital admission by 31.8% of participants. These findings suggest that a subset of young adults with premature graying may also have broader health-related exposures or systemic conditions. Previous literature has discussed associations between premature graying and autoimmune disease, endocrine disorders, atopy, cardiovascular risk factors, and nutritional or metabolic abnormalities (20). Nevertheless, the present data do not provide disease-specific clinical diagnoses in sufficient detail to determine which comorbidities were most relevant. Future studies should include structured assessment of thyroid disease, autoimmune disorders, anemia, vitamin B12 deficiency, ferritin status, vitamin D deficiency, metabolic syndrome indicators, and medication exposures to clarify which clinical factors remain independently associated with premature graying after adjustment for age, sex, smoking, diet, and family history.

The descriptive finding that oily scalp was reported by 55.9% of participants should be interpreted cautiously. Although scalp type may reflect sebaceous activity, local follicular environment, grooming behavior, or self-perceived hair condition, the relationship between oily scalp and premature graying is not well established. Any suggestion that oily scalp is protective or harmful would require valid group-wise analysis and ideally longitudinal confirmation. In the corrected version of the Results, scalp type is therefore best presented as part of the descriptive hair-health profile rather than as a confirmed predictor. Similarly, physical activity, dietary supplements, smoking intensity, and specific viral infection history should be interpreted descriptively unless valid inferential comparisons are regenerated from the cleaned dataset.

This study has several strengths. It addresses an underreported topic in Pakistan, includes a relatively large young-adult sample, and assesses a broad range of demographic, lifestyle, nutritional, psychological, clinical, hair-related, and familial characteristics. The study also highlights a practical clinical issue because premature graying is often dismissed as cosmetic, despite its possible association with modifiable exposures and psychosocial distress. However, several limitations must be acknowledged. The cross-sectional design prevents causal inference and does not establish whether exposures preceded the onset of graying. The online convenience-sampling approach may limit generalizability, particularly because the sample was predominantly student-based and may not represent all young adults in Lahore or Pakistan. Self-reported graying, anxiety, depression, diet, deficiency status, comorbidities, and treatment use may be affected by recall bias, reporting bias, and social desirability bias. The absence of dermatological confirmation, standardized hair examination, validated psychological scales, and laboratory verification of nutritional deficiencies further limits clinical precision. Most importantly, the original manuscript tables contained inconsistent denominators and an incompatible regression table; therefore, the corrected interpretation should rely on verified aggregate descriptive data until the raw dataset or corrected statistical output is reanalyzed.

Overall, the study suggests that premature graying before the age of 30 years is common among young adults in this Lahore-based sample and occurs alongside frequent family history, hair loss, nutritional deficiency, smoking exposure, psychological symptoms, and selected clinical factors. These findings

support the need for careful clinical assessment of young adults presenting with early graying, including attention to family history, diet, micronutrient status, smoking, psychological wellbeing, and coexisting hair loss. Future research should use probability-based or multi-center sampling, standardized clinical assessment of graying severity, validated mental health instruments, laboratory-confirmed nutritional markers, and prospectively collected exposure data. A corrected multivariable analysis from the cleaned dataset would be essential to determine which factors remain independently associated with premature graying in this population.

CONCLUSION

Premature graying of hair before the age of 30 years was common among young adults in this Lahore-based sample, with a corrected descriptive prevalence of 55.2%. The condition was observed in the context of frequent family history, hair loss, vitamin or mineral deficiency, smoking exposure, unhealthy dietary patterns, anxiety, depression, and selected clinical factors. These findings suggest that premature graying in young adults is likely multifactorial, involving hereditary susceptibility alongside potentially modifiable lifestyle, nutritional, psychological, and health-related factors. Because the study was cross-sectional and based on self-reported data, the findings should be interpreted as associations and descriptive patterns rather than causal relationships. Clinical and public health approaches should emphasize awareness, smoking cessation, nutritional evaluation, psychological wellbeing, and appropriate assessment of coexisting hair-loss or systemic conditions. Future longitudinal studies with dermatological confirmation, laboratory-based nutritional assessment, and corrected multivariable modeling are needed to identify independent predictors and clarify the temporal pathways leading to premature graying in young adults.

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