The prevalence of hair loss and its association with iron deficiency among adolescents in northern Sudan: a school-based cross-sectional study

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Abstract

Introduction: Alopecia and iron deficiency are significant public health issues in northern Sudan, and no research about this topic has been conducted. The aim is to examine the prevalence of iron deficiency and alopecia and associated factors among adolescents in northern Sudan.
Methods: A cross-sectional study was conducted through a questionnaire and clinical examination.
Results: A total of 312 adolescents participated: 147 males (47.1%) and 165 females (52.9%). Among them, 21.2% of adolescents exhibited alopecia. Females experienced higher rates of alopecia, with 93.9% affected compared to 6.1% of males. Serum ferritin was significantly lower in adolescents with alopecia compared to those without it (6.05 [2.58-12.63] vs. 9.40 [4.88-23.40] μg/l, p = 0.002). Multivariate analysis indicated that iron deficiency (adjusted odds ratio [AOR] = 1.97, 95% confidence interval [CI] = 1.04–3.71) was associated with alopecia. However, age, body mass index, and parental education level showed no association. Among the adolescents with alopecia, 27.3% had patchy alopecia, 37.9% had diffuse alopecia, and 34.8% had traction alopecia.
Conclusions: There is a significant prevalence of adolescent alopecia, predominantly among females. Iron deficiency was a key factor associated with alopecia, underscoring the importance of nutritional monitoring in this population.

Keywords: adolescents, alopecia, iron deficiency, age, Sudan

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Introduction

There is an increasing trend of alopecia, particularly among adolescents across the globe, and Africa is no exception (1–4). Different types of alopecia have been reported in children and adolescents, such as alopecia areata (5–7), androgenetic alopecia (6–8), and traction alopecia (7). All these types of alopecia exert various negative impacts on children's and adolescents' health, including their psychiatric morbidity, quality of life (5, 9, 10), self-image, and self-esteem (8). The early identification of alopecia is essential, especially among children and adolescents, to provide a chance for early intervention that will lower the negative impact on quality of life (3). Alopecia may be the first symptom of systemic illness (9). In female adolescents, alopecia may be a sign of underlying androgen excess, particularly polycystic ovary syndrome (PCOS) (6).

Recently, more attention has been devoted to the role of iron deficiency in alopecia, particularly among females (11–16). However, these studies have yielded contradictory results (13, 15, 16). Although some studies have reported an association (14, 16), others have reported no association (13). The essential role of iron in the pathogenesis and treatment of alopecia is an evolving and expanding area of study (17).

A high prevalence of alopecia in adolescents has been reported in various countries such as Nigeria (35.6%) (2) and Turkey (37.4%) (3) among both male and female adolescents, and in Egypt (28.6%) among female adolescents (4). Researchers have explored the association between alopecia among adolescents and several factors such as age, sex, high body mass index (BMI), parental education level, and occupational status (3, 4, 18, 19). Although various studies have started to explore the epidemiology of alopecia in adolescents across Africa, such as in Nigeria and Egypt (2, 4, 20), comprehensive research focusing on Sudanese adolescents is still necessary.

There are few studies on alopecia in Sudan (21–23), and none have explored alopecia and its possible relation to iron deficiency among adolescents. In addition, previous studies have revealed that both alopecia and iron deficiency are public health problems in Sudan (21–25). Iron deficiency has been reported among various Sudanese populations, including adolescents (25). Therefore, this study examines the prevalence and associated factors, including iron deficiency, of alopecia among adolescents in Al Matammah, River Nile State, Sudan to fill the significant gap in current knowledge.

Methods

Study area

This school-based cross-sectional study was conducted among 312 adolescents 10 to 19 years old at public schools in Al Matammah, Sudan, from June to September 2022. Al Matammah, located in River Nile State and approximately 130 km from Khartoum, the capital of Sudan, is home to public schools for both boys and girls. A list of students within the specified age range was obtained from the school administrations, and participants were randomly selected from this list.

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Inclusion and exclusion criteria

All adolescents age 10 to 19 were included in the study, and those outside this age range were excluded. Participants that did not consent to take part were also excluded. All recruited participants were in apparent positive health; individuals that were sick, pregnant, or lactating were excluded due to the potential impact on hair growth.

Data collection

This study was performed according to the Guidelines for Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) (26). The relevant information (presence or absence of alopecia and possible associated factors) was collected from the participants by administering a questionnaire and conducting a hair and scalp examination for alopecia. The questionnaire was designed to collect relevant information according to previous studies (2–4, 18, 27). The investigators trained four medical officers (two of each sex) with dermatology experience to conduct the fieldwork. The questionnaire included information about participants' sociodemographic characteristics, such as age in years, sex (males/females), parental education level (< secondary, ≥ secondary), and occupational status (employed or unemployed). During the examination, the adolescents' hair and scalp were assessed, and additional details regarding their hair and scalp health were collected, including patterns of alopecia—either patchy (one or more localized distinct areas of hair loss) or diffuse (an overall thinning of hair across the scalp, without distinct patches)—hair traction, and the duration of their alopecia. Participants' weights were measured in kilograms using well-calibrated scales, which were reset to zero before each measurement. Their weight was recorded to the nearest 100 grams, with participants standing still, hands at their sides, and without shoes or excess clothing. Their height was measured to the nearest 0.1 cm, with participants standing straight against the wall with their feet together. BMI was calculated based on participants' age, sex, weight, and height (28).

Blood sample processing

Under aseptic conditions, all participants were asked to provide a 5 ml blood sample; 2 ml was collected in a tube containing EDTA for hemoglobin analysis, and the remaining 3 ml was placed in a plain tube for serum ferritin testing. The hemoglobin analysis was performed using the Sysmex KX-21 according to the manufacturer's instructions (Diamond diagnostics, Japan). In this study, anemia was defined based on the World Health Organization's (WHO) criteria, which specify hemoglobin levels of < 12 g/dl for females and < 13 g/dl for males (29). The remaining 3 ml blood samples were allowed to clot, centrifuged, and stored at –20 °C until laboratory analysis for serum ferritin. Serum ferritin was measured using a radioimmunoassay gamma counter, and kits were supplied by Beijing Isotope Nuclear Electronic Co. (Beijing, China), as detailed in our previous study (25). Based on the WHO guideline, the cutoff value to define iron deficiency in apparently healthy adolescents is a serum ferritin level of < 15 µg/l (30).

Sample size calculation

The sample size was calculated using the OpenEpi Menu. This study enrolled 312 adolescents. This sample size was determined based on the assumption that approximately one-third of adolescents would experience alopecia, as reported in previous studies such as those conducted in Nigeria (35.6%) (2) and Turkey (37.4%) (3). Based on the previous report in Sudan, it was further assumed that 60% of adolescents with alopecia would have iron deficiency, and that 40% of the adolescents without alopecia would have iron deficiency. This sample size was designed to detect a 5% difference at α = 0.05, with a power of 80% (31).

Ethical statement

This study was conducted in accordance with the Declaration of Helsinki. The study was approved by the ethical board of the Faculty of Medicine at the University of Khartoum in Sudan, under reference number 9 2021. All participants (with their guardians) signed a written informed consent form. The authors followed all measures to ensure participants' privacy and confidentiality, such as excluding personal identifiers during data collection.

Statistical analysis

The data were analyzed using IBM Statistical Package for the Social Sciences (SPSS) for Windows, version 22.0 (SPSS Inc., New York, USA). Proportions were presented as percentages. The Kolmogorov–Smirnov test was conducted to assess the normality of continuous data, such as age, BMI, and serum ferritin, which indicated a non-normal distribution. Consequently, age, BMI, and serum ferritin were reported based on the corresponding median values like interquartile range (IQR). Initially, a univariate analysis was performed, with alopecia as the dependent variable and sociodemographic factors (adolescents' sex, age, BMI, and parental education and occupation), iron deficiency, iron-deficiency anemia, and anemia as independent variables. A multivariate analysis followed, including variables with a p-value < 0.200 to control for confounding factors, excluding variables with low frequencies, such as sex. Adjusted odds ratios (AORs) and 95% confidence intervals (CIs) were calculated, with a two-sided p-value of < 0.05 considered statistically significant.

Results

A total of 312 adolescents participated in the study, comprising 147 males (47.1%) and 165 females (52.9%). Regarding parental education, 191 mothers (61.2%) had completed at least secondary education, and 121 (38.8%) had completed less than secondary education. For fathers, 208 (66.7%) achieved at least secondary education, and 104 (33.3%) had less. Furthermore, 35 mothers (11.2%) were employed, and 277 (88.8%) were unemployed. In comparison, 179 fathers (67.4%) were employed, and 133 (42.6%) were unemployed. Among the 312 adolescents, 183 (58.7%) had iron deficiency, 57 (18.3%) had iron-deficiency anemia, and 77 (24.7%) had anemia.

Among the participants, 66 (21.2%) experienced alopecia, and 246 (78.8%) did not. Female adolescents experienced higher rates of alopecia, with 62 (93.9%) affected compared to four (6.1%) among males. Of the 165 female participants, 62 (37.5%) experienced alopecia, whereas only four (2.7%) of the 147 male participants experienced this condition. The median age was 15.3 years (IQR: 14.0–16.4), and the median BMI was 18.6 kg/m² (IQR: 16.7–21.7). The median serum ferritin levels were 8.25 µg/l (IQR: 4.03–21.77); this was significantly lower in adolescents that expe-

rienced alopecia compared to those that did not: 6.05 (2.58-12.63) versus 9.40 (4.88-23.40, p = 0.002) μg/l. In the univariate analysis, factors positively associated with alopecia included being female and having iron deficiency. Other variables, such as age, BMI, parental education and occupation, iron-deficiency anemia, and anemia, were not associated with alopecia (Table 1).

Multivariate analysis indicated that iron deficiency (AOR = 1.97, 95% CI = 1.04–3.71) was positively associated with alopecia, whereas age, BMI, and parental education levels showed no association (Table 2). Among the 66 adolescents with alopecia, 18 (27.3%) had patchy alopecia, 25 (37.9%) had diffuse alopecia, and 23 (34.8%) had traction alopecia.

Discussion

The main findings of this study were that one out of five (21.2%) adolescents in northern Sudan had alopecia, predominantly among females, and iron deficiency was associated with alopecia in adolescents in northern Sudan. The present high prevalence of alopecia among adolescents (21.2%) is consistent with our previous study, which reported that one in four women is affected by traction alopecia in northern Sudan (23). This study supports the vulnerability of females to alopecia compared to males (31, 32). This high prevalence of alopecia among female adolescents in this study (37.5%) is comparable with that in a previous cross-sectional study in neighboring Egypt, which included 3,405 secondary school girls and reported an overall female pattern alopecia prevalence of 28.6% among secondary school girls, with a significant predominance in rural over urban areas (4). In Turkey, a study that included 1,662 high-school students (males and females) in rural areas revealed a prevalence of alopecia of 37.4% (3). In Turkey, however, alopecia was more commonly observed among male students that reported scalp complaints (3). Such a high prevalence of alopecia among females may indicate poor knowledge among female adolescents, as reported in African contexts (20). In addition, as in this study and other studies, female adolescents are particularly more susceptible to iron deficiency, iron-deficiency anemia, and iron depletion compared to their male counterparts (33, 34).

In this study, serum ferritin levels were significantly lower in adolescents that experienced alopecia compared to those that did not. Several studies found similar findings (11, 14). For instance, Park et al. reported significantly lower serum ferritin levels in patients with female pattern alopecia compared to normal healthy women. Furthermore, in their systematic review and meta-analysis, Treister-Goltzman et al. reported that women with alopecia can benefit from higher ferritin levels (11). This study supports the early screening of iron status among adolescents with alopecia and thorough hair examinations of adolescents with low ferritin or iron deficiency. The timely detection of iron deficiency in the body allows corrective measures to improve adolescents' overall conditions, including their hair health (35).

This study corroborates previous studies that addressed the association between iron deficiency and alopecia, including androgenetic alopecia, telogen effluvium, and diffuse alopecia (14, 16). On the other hand, Wani and Jan reported no association between the levels of serum iron and ferritin and alopecia areata; they attributed this lack of association to the immunogenetic factors underlying alopecia areata compared to other types of alopecia (13). Interestingly, iron deficiency, rather than iron-deficiency anemia or anemia itself, is associated with alopecia in this study. This indicates the direct impact of iron on hair follicle health and

functioning in adolescents. Iron plays a crucial role in various biological processes, including oxygen transport and cellular metabolism, which are essential for hair growth, as detailed below.

First, iron has a direct influence on hair growth. Iron deficiency can lead to disruptions in the hair growth cycle, resulting in conditions such as telogen effluvium, which is characterized by increased hair shedding. Studies have revealed that, even in the absence of anemia, low serum ferritin levels (an indicator of iron stores) are associated with alopecia in females (36).

Second, the prevalence of iron deficiency is an issue. Many adolescents may experience iron deficiency without progressing to anemia. This is particularly relevant in populations with dietary restrictions or increased physiological demands, such as during adolescence, when growth spurts occur (33, 37). For instance, a review highlighted the widespread prevalence of iron deficiency in children and adolescents, emphasizing its implications for overall health and growth (35). Although treating iron deficiency without anemia is a topic of debate (16, 36, 37), these findings support the use of iron supplementation, regardless of anemia status, particularly concerning hair health.

Third, iron plays a role in hair follicle function. Research has indicated that iron is essential for the proliferation of keratinocytes in hair follicles, and low iron levels can impair the hair growth cycle, potentially leading to alopecia (15, 38). A study found that women with alopecia frequently had low ferritin levels, regardless of whether they met the criteria for anemia (38). Therefore, focusing on iron deficiency rather than iron-deficiency anemia or anemia allows for earlier interventions and management strategies to prevent alopecia in adolescents because iron deficiency may occur before the development of anemia, and it significantly impacts hair health.

In this study, other factors such as adolescents' age and BMI, parental education and occupation, iron-deficiency anemia, and anemia were not found to be associated with alopecia among adolescents. Likewise, other studies found no association between adolescent alopecia and adolescents' age, BMI, parental education, and occupational status (3, 4, 19).

The findings of this study have important implications for improving adolescents' hair health because alopecia progression could be prevented when recognized early. This can be achieved through various preventive measures, including promoting a healthy diet, implementing early screening programs, and encouraging lifestyle modifications such as avoiding certain hairstyles and practicing proper hair care. The results of this study will be shared with healthcare professionals and authorities, particularly in Al Matammah, to address hair health issues among adolescents. As an immediate outcome, adolescents identified with alopecia received recommendations from medical officers to seek further evaluations and management at nearby healthcare facilities. However, the ongoing conflict in Sudan presents significant challenges related to implementing these recommendations because it exacerbates mental health disorders and sleep quality issues, which can further contribute to alopecia (39). On the other hand, as previously mentioned, alopecia negatively impacts mental health disorders such as depression and anxiety, quality of life, social and romantic relationships, self-image, self-esteem, family dynamics, occupation, productivity, and finances in adolescents (5, 8, 10, 40–45). In addition, conflict can influence the quality and availability of food, particularly among vulnerable populations such as children, adolescents, and women (46); the ongoing conflict in Sudan has significantly disrupted the health-

Table 1 | Univariate analysis of factors associated with hair loss among adolescents in northern Sudan (*n* = 312).

Variables		Total (*n* = 312)	Adolescents with hair loss (*n* = 66)	Adolescents without hair loss (*n* = 246)	Odds ratio (95% CI)	*p*-value
Median (interquartile range)						
Age, years		15.3 (14.0–16.4)	15.7 (14.3–16.5)	15.2 (13.9–16.3)	1.17 (0.98–1.39)	0.078
BMI, kg/m²		18.6 (16.7–21.7)	19.3 (17.3–21.9)	18.5 (16.4–21.7)	1.05 (0.98–1.13)	0.160
Frequency (percentage)						
Sex	Male	147 (47.1)	4 (6.1)	143 (58.1)	Reference	‹ 0.001
	Female	165 (52.9)	62 (93.9)	103 (41.9)	21.52 (7.59–61.03)	
Mother's education	≥ Secondary	191 (61.2)	45 (68.2)	146 (59.3)	Reference	0.193
	‹ Secondary	121 (38.8)	21 (31.8)	100 (40.7)	0.68 (0.38–1.21)	
Father's education	≥ Secondary	208 (66.7)	50 (75.8)	158 (64.2)	Reference	0.080
	‹ Secondary	104 (33.3)	16 (24.2)	88 (35.8)	0.57 (0.31–1.07)	
Mother's job status	Employed	277 (88.8)	58 (87.9)	219 (89.0)	Reference	0.794
	Unemployed	35 (11.2)	8 (12.1)	27 (11.0)	0.89 (0.39–2.07)	
Father's job status	Employed	179 (57.4)	35 (53.0)	144 (58.5)	Reference	0.422
	Unemployed	133 (42.6)	31 (47.0)	102 (41.5)	0.80 (0.46–1.38)	
Iron deficiency	No	129 (41.3)	18 (27.3)	111 (45.1)	Reference	0.010
	Yes	183 (58.7)	48 (72.7)	145 (54.9)	2.19 (1.21–3.98)	
Iron-deficiency anemia	No	255 (81.7)	53 (80.3)	202 (82.1)	Reference	0.735
	Yes	57 (18.3)	13 (19.7)	44 (17.9)	1.13 (0.57–2.24)	
Anemia	No	235 (75.3)	50 (75.8)	185 (75.2)	Reference	0.926
	Yes	77 (24.7)	16 (24.2)	61 (24.8)	0.92 (0.52–1.82)	

BMI = body mass index, CI = confidence interval.

care system, including the workforce (47). All these circumstances can lead to alopecia due to deficiencies in the essential nutrients necessary for hair growth, such as iron (16, 48, 49). However, further research is necessary to confirm these findings and to investigate the relationship between hair, scalp, and skin characteristics and alopecia, particularly for each type of alopecia (patchy, diffuse, or traction) (50). Finally, Xu et al. developed a practical approach to the common causes, diagnosis, and management of alopecia in children and adolescents, which could be applicable in our context until a localized approach is established (7).

However, this study has some limitations that should be mentioned to improve future research designs. It was conducted in a single region of northern Sudan and may not represent the entire country, which is characterized by a multiethnic population. In addition, this study did not include adolescents in urban areas, in which different cultures regarding hairdressing and hair care practices may exist between urban and rural communities (4); as a result, such cultural differences could affect adolescents' susceptibility to alopecia. For example, researchers reported urban–rural differences in the prevalence of female pattern alopecia among secondary school girls (4). Therefore, a sizable study including different regions of Sudan (urban and rural) is needed to quantify the alopecia problem at the national level and to develop a precise interventional strategy. In addition, in this study, iron deficiency was measured based on serum ferritin rather than serum iron concentrations. However, the serum ferritin levels may be elevated by certain health conditions such as infectious inflammatory conditions and anemia of chronic disease (16, 51). Our study in eastern Sudan among adolescents suggested the use of hemoglobin and red blood cell parameters to diagnose iron deficiency to avoid additional expenses for patients (52, 53).

Table 2 | Adjusted multivariate analysis for factors associated with hair loss.

Variables		Odds ratio	95% CI	*p*-value
Age, years		1.03	0.85–1.26	0.713
BMI, kg/m²		1.04	0.96–1.13	0.369
Mother's education	≥ Secondary	Reference		0.646
	‹ Secondary	0.84	0.42–1.71	
Father's education	≥ Secondary	Reference		0.232
	‹ Secondary	0.64	0.30–1.33	
Iron deficiency	No	Reference		0.037
	Yes	1.97	1.04–3.71	

BMI = body mass index, CI = confidence interval.

Conclusions

To the authors' knowledge, this study is the first to explore the epidemiology of alopecia and its association with iron status among Sudanese adolescents. The findings contribute valuable insights to the limited studies on alopecia in Sudan. The adolescents identified with alopecia were advised to consult a dermatologist for further evaluation and management of possible associated morbidities such as insulin resistance, hyperandrogenemia, and PCOS. These results can help decision-makers, healthcare professionals, and educational professionals enhance children's and adolescents' hair health because alopecia is a preventable, treatable, and reversible condition, particularly when identified in its early stages.

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References

1. Palmer V, Valdebran M. Central centrifugal cicatricial alopecia in the adolescent population: an overview of available literature. Life. 2023;13:1022.

2. Sani H, Ogunbiyi O, George A, Okoro O. Prevalence and pattern of alopecia in secondary and tertiary institutions in Ibadan. Sub-Saharan African J Med. 2016;3:148.

3. Ozay O, Arslantas D, Unsal A, Bulur I. The frequency of alopecia and quality of life in high-school students in rural areas (Sivrihisar, Mahmudiye, Alpu, Beylikova) of Eskisehir. North Clin Istanbul. 2018;6:226–35.

4. Youssef SME, Atallah RB, Zaky MS, Eldeek BS, Elsaie ML. Urban–rural differences in the prevalence of female pattern hair loss among secondary school girls: a cross-sectional study. J Cosmet Dermatol. 2022;21:2229–35.

5. Bilgiç Ö, Bilgiç A, Bahalı K, Bahali AG, Gürkan A, Yılmaz S. Psychiatric symptomatology and health-related quality of life in children and adolescents with alopecia areata. J Eur Acad Dermatol Venereol. 2014;28:1463–8.

6. Bedocs LA, Bruckner AL. Adolescent hair loss. Curr Opin Pediatr. 2008;20:431–5.

7. Xu L, Liu KX, Senna MM. A practical approach to the diagnosis and management of hair loss in children and adolescents. Front Med. 2017;4:112.

8. Price VH. Androgenetic alopecia in adolescents. Cutis. 2003;71:115–21.

9. Chan L, Cook DK. Female pattern hair loss. Aust J Gen Pract. 2018;47:459–64.

10. Ghanizadeh A. Comorbidity of psychiatric disorders in children and adolescents with alopecia areata in a child and adolescent psychiatry clinical sample. Int J Dermatol. 2008;47:1118–20.

11. Treister-Goltzman Y, Yarza S, Peleg R. Iron deficiency and nonscarring alopecia in women: systematic review and meta-analysis. Skin Appendage Disord. 2022;8:83–92.

12. Younus Shah F, Shafat Kitab I, Younis Shah F, Aslam Shah A, Khursheed Dar U, Tasaduq I, et al. Role of iron deficiency in male pattern hair loss. Int J Contemp Med Res. 2020;7:J1–3.

13. Wani AA, Jan N. Serum iron and ferritin levels in alopecia areata. Iran J Dermatology. 2011;14:92–4.

14. Park SY, Na SY, Kim JH, Cho S, Lee JH. Iron plays a certain role in patterned hair loss. J Korean Med Sci. 2013;28:934–8.

15. Elston DM. Commentary: iron deficiency and hair loss: problems with measurement of iron. J Am Acad Dermatol. 2010;63:1077–82.

16. Trost LB, Bergfeld WF, Calogeras E. The diagnosis and treatment of iron deficiency and its potential relationship to hair loss. J Am Acad Dermatol. 2006;54:824–44.

17. Gokce N, Basgoz N, Kenanoglu S, Akalin H, Ozkul Y, Ergoren MC, et al. An overview of the genetic aspects of hair loss and its connection with nutrition. J Prev Med Hyg. 2022;63:e228–38.

18. Kadiyala P, Rajalakshmi H, Mer HT, Vinodhini B, Borkar RS, Merlin G. Prevalence of hair loss and its associated factors among medical and paramedical students of a tertiary care hospital, Chennai. Afr J Biomed Res. 2024;27:7571–8.

19. Özcan D. Pediatric androgenetic alopecia: a retrospective review of clinical characteristics, hormonal assays and metabolic syndrome risk factors in 23 patients. An Bras Dermatol. 2022;97:166–72.

20. Okoro OE, Imam A, Barminas R. Knowledge of traction alopecia and hair care practices among adolescents in Keffi, North-Central Nigeria. Skin Appendage Disord. 2022;8:129–35.

21. Khogali AO, El-Kordofani M, Mithani A, Ramadan ARM, Elhassan GO, Muddathir AK, et al. Clinicoepidemiological study prevalence and types of alopecia areata in Khartoum Dermatology Teaching Hospital, Outpatient Clinic, Khartoum, Sudan. Am J Dermatology Venereol. 2016;5:39–45.

22. Suad HH, Modawe GA. Investigation of diffuse hair fall case due to vitamin D deficiency: a case report and literature review. Sudan J Med Sci. 2018;13:91.

23. Abdallah S, Hassan AA, Alotaibi MK. Prevalence and associated factors of traction alopecia in women in north Sudan: a community-based, cross-sectional study. Medicina (B Aires). 2025;61:195.

24. Abdelrahim IIII, Mahgoub HMHM, Mohamed AAA, Ali NINI, Elbashir MIMI, Adam I. Anaemia, folate, zinc and copper deficiencies among adolescent schoolgirls in eastern Sudan. Biol Trace Elem Res. 2009;132:60–6.

25. Abbas W, Adam I, Rayis DA, Hassan NG, Lutfi MF. Higher rate of iron deficiency in obese pregnant Sudanese women. Open Access Maced J Med Sci. 2017;5:285–9.

26. 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. J Clin Epidemiol. 2008; 61:344–9.

27. Losoya-Jaquez MR, Yañez-Blanco AL, Armendariz-Barragan Y, Aguilar-Figueroa NG, Rudnicka L, Sanchez-Dueñas LE. Androgenetic alopecia in children and adolescents: from trichoscopy to therapy. Skin Appendage Disord. 2023;10:123–8.

28. World Health Organization. BMI-for-age (5–19 years) [Internet]. Geneva, Switzerland; [cited 2023 Jan 29]. Available from: https://www.who.int/toolkits/growth-reference-data-for-5to19-years/indicators/bmi-for-age.

29. World Health Organization. Vitamin and mineral nutrition information system. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity [Internet]. Geneva; 2011 [cited 2023 Sep 2]. Available from: https://apps.who.int/iris/bitstream/handle/10665/85839/WHO_NMH_NHD_MNM_11.1_eng.pdf?ua=1.

30. World Health Organization. WHO guideline on use of ferritin concentrations to assess iron status in individuals and populations. Geneva; 2020.

31. Osman HM, Osman AA, Al-Nafeesah A, AlEed A, Adam I. Prevalence and associated factors of anaemia and iron-deficiency anaemia among adolescent Sudanese schoolchildren: a cross-sectional study. J Trop Pediatr. 2024;71:fmae047.

32. Mostaghimi A, Gao W, Ray M, Bartolome L, Wang T, Carley C, et al. Trends in prevalence and incidence of alopecia areata, alopecia totalis, and alopecia universalis among adults and children in a US employer-sponsored insured population. JAMA Dermatol. 2023;159:411–8.

33. Shakibaei A, Rezazadeh H, Mohseni E, Torbatinejad A, Ghadam A, Azarang M, et al. Causes and treatments of hair loss: a cross-sectional study. Clin Cancer Investig J. 2023;12.

34. Andriastuti M, Ilmana G, Nawangwulan SA, Kosasih KA. Prevalence of anemia and iron profile among children and adolescent with low socio-economic status. Int J Pediatr Adolesc Med. 2020;7:88–92.

35. Du Plessis T, Moxley K, Lachman A. Prevalence of iron deficiency in a South African adolescent inpatient psychiatric population: rates, risk factors and recommendations. South African J Psychiatry. 2019;25:a1347.

36. Marushko YV, Moskovenko OD. Problems of iron deficiency in children and adolescents: diagnosis, quality of life, treatment (literature review). Fam Med Eur Pract. 2023;2023:57–63.

37. Triwongwaranat D, Thanomkitti K, Wongdama S, Jantanapornchai N, Subchookul C, Likitwattananurak C, et al. Efficacy of oral iron supplementation in treating patients with female pattern hair loss and low serum ferritin: a pilot study. Siriraj Med J. 2023;75:759–62.

38. Chaber R, Helwich E, Lauterbach R, Mastalerz-Migas A, Matysiak M, Peregud-Pogorzelski J, et al. Diagnosis and treatment of iron deficiency and iron deficiency anemia in children and adolescents: recommendations of the Polish Pediatric Society, the Polish Society of Pediatric Oncology and Hematology, the Polish Society of Neonatology, and the Polish Society of Family Medicine. Nutrients. 2024;16:3623.

39. Siddiqua A, Rahaman MM, Tauseef S. Association of ferritin and vitamin-D (calciferol) deficiency with female pattern hair loss. IAHS Med J. 2023;6:3–5.

40. Natarelli N, Gahoonia N, Sivamani RK. Integrative and mechanistic approach to the hair growth cycle and alopecia. J Clin Med. 2023;12:893.

41. Lauron S, Plasse C, Vaysset M, Pereira B, D'Incan M, Rondepierre F, et al. Prevalence and odds of depressive and anxiety disorders and symptoms in children and adults with alopecia areata: a systematic review and meta-analysis. JAMA Dermatology. 2023;159:281–8.

42. Malik SS, Naveed T, Naveed S, Minhas IJ, Khan BM, Sadiq S. Using Skindex-29 scale to assess the impact of androgenetic/patterned hair loss on quality of life of patients in Pakistan. Pakistan Armed Forces Med J. 2022;72:42–6.

43. Hwang HW, Ryou S, Hyeong Jeong J, Lee JW, Lee KJ, Lee SB, et al. The quality of life and psychosocial impact on female pattern hair loss. Ann Dermatol. 2024; 36:44–52.

44. Mohamed NE, Soltan MR, Galal SA, El Sayed HS, Hassan HM, Khatery BH. Female pattern hair loss and negative psychological impact: possible role of brain-derived neurotrophic factor (BDNF). Dermatol Pract Concept. 2023;13:e2023139.

45. Muntyanu A, Gabrielli S, Donovan J, Gooderham M, Guenther L, Hanna S, et al. The burden of alopecia areata: a scoping review focusing on quality of life, mental health and work productivity. J Eur Acad Dermatol Venereol. 2023;37:1490–520.

46. Prendke M, Kanti-Schmidt V, Wilborn D, Hillmann K, Singh R, Vogt A, et al. Quality of life in children and adolescents with alopecia areata—a systematic review. J Eur Acad Dermatol Venereol. 2023;37:1521–34.

47. Parigi M. The effect of violent conflict on calorie consumption and dietary quality in Iraq. J Agric Econ. 2024;75:341–61.

48. Badri R, Dawood I. The implications of the Sudan war on healthcare workers and facilities: a health system tragedy. Confl Health. BioMed Central; 2024;18:22.

49. Guo EL, Katta R. Diet and hair loss: effects of nutrient deficiency and supplement use. Dermatol Pract Concept. 2017;7:1–10.

50. Mohamed H, Abdel-Razek R, Isshak M. Epidemiology of traction alopecia among school students in Minia, Upper Egypt. Ain Shams Med J. 2023;74:757–62.

51. Sharquie KE, Schwartz RA, Aljanabi WK, Janniger CK. Traction Alopecia: Clinical and Cultural Patterns. Indian J Dermatol. 2021;66:445.

52. Weiss G, Goodnough L. Anemia of chronic disease. N Engl J Med. 2005;352:1011–23.

53. Alsafi WM, Gaffer AA, Al-Nafeesah Q, Aleed A, Alfaifi J, Adam I. Diagnostic accuracy of hemoglobin levels and red blood cell parameters for iron deficiency in adolescents: a cross-sectional study. Glob Pediatr Heal. 2024;11:2333794X241304642.