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Mapping evidence on the impact of junk food on anaemia among adolescent and adult population: a scoping review

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Abstract

Background Anaemia is a significant global health issue, with adolescents being a particularly vulnerable group. In developing countries, 27% of adolescents are affected by anaemia, compared to a much lower prevalence of 6% in developed countries. This scoping review aims to investigate the intake of junk food and the development of anaemia, providing a foundation for future research in this field.

Methods A systematic search was conducted across Scopus, PubMed, EBSCO, CINHAL, WOS and ProQuest using specific keywords. Inclusion criteria comprised all quantitative studies examining the association between nutrition and the development of anaemia. Articles selected for analysis were restricted to those published in English Language between 2014–2024 and available as full-text articles.

Results Among the articles that were screened, 20 articles met the criteria for data extraction. Four studies did not reveal statistically significant correlations between nutrition and the development of anaemia, while two studies provided evidence for significant associations. The findings indicated increased anaemia was associated with (a) fast food intake, western pattern of diet, poor eating habits, omission of breakfast and (b) diminished consumption of fruits and vegetables, iron intake, seafood, nuts, and seeds.

Conclusion The existing evidence suggests a link between the consumption of junk food and the prevalence of anaemia among adolescents. However, there is a lack of comprehensive studies that thoroughly explore this connection. This gap in research underscores the urgent need for more in-depth studies to understand how modifiable risk factors like junk food consumption contribute to anaemia in adolescents, with the goal of improving prevention and management strategies. Addressing this issue aligns with Sustainable Development Goal (SDG) 3, which aims to ensure healthy lives and promote well-being for all at all ages, which focuses on ending preventable deaths of children and addressing adolescent health. Additionally, this research also contributes to end hunger, achieve food security, and improve nutrition.

Keywords Anaemia, Junk food, Adolescents, Consumption, Wellbeing

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Background

Anaemia is among the most prevalent nutritional disorders worldwide, affecting approximately one-third of the global population, largely due to iron deficiency. According to the World Health Organization, nearly two billion people, or about 25% of the global population, are affected by anaemia, with approximately half of these cases resulting from iron deficiency anaemia (IDA) [1]. Among adolescents, the most significant risk factors for IDA include poor food intake practices, female gender, menstruation, parasitic infections, inadequate educational qualifications [2], and low economic status [3].

Iron deficiency is the leading predictor of anaemia, followed by other factors such as haemoglobinopathies, vitamin A deficiency, and zinc deficiency [4]. Malnutrition, which includes both undernutrition and over nutrition, plays a crucial role in the development of anaemia. In South Asian countries, one in three people is malnourished, driven by poor diet quality, inadequate healthcare, and broader socio-economic factors like political instability, low economic development, and inequality [5].

Anaemia adversely affects cognitive function in adolescents by disrupting neurotransmitter production, delaying brain development, and impairing cognitive processing. Addressing anaemia through proper nutrition and medical treatment is essential for supporting healthy cognitive development during this crucial stage of life [6].

Dietary deficiencies are a major cause of anaemia, with cultural practices and perceptions about diet significantly influencing food choices. Research on adolescent girls has shown that while there is some awareness that poor diet can lead to anaemia, there is often limited knowledge about the specific dietary elements necessary to prevent it [7]. Junk food consumption exacerbates this issue by displacing nutrient-rich foods in the diet, leading to further nutritional deficiencies [8]. Adolescents, in particular, are prone to consuming snacks made from refined cereals and carbonated drinks, while showing a lower inclination towards fruits and vegetables, which are essential sources of iron and other vital nutrients [9].

The widespread consumption of junk food, which provides empty calories but lacks essential nutrients like iron, vitamin A, and zinc, directly contributes to the development of anaemia [8]. Popular foods like street snacks with black rock salt, soft drinks, and pre-packaged spice mixes often lack the essential nutrients required to support healthy iron levels, which can elevate the risk of anaemia [10]. Furthermore, IDA is a preventable and treatable condition, but it often goes unaddressed due to poor dietary habits and a lack of awareness about the importance of nutrient-rich foods [1, 6]. This review aims to explore the overlooked relationship between junk food consumption and the development of anaemia, particularly in adolescents. By identifying gaps in the existing literature, this review will shed light on the nutritional deficiencies caused by junk food and their contribution to the rising incidence of anaemia. Understanding these gaps are crucial for developing targeted interventions and public health strategies to combat anaemia, especially in vulnerable populations such as adolescent girls.

Methods and Materials

This review followed a scoping review methodology, we explored evidence to gain a deeper understanding on consumption of junk food to anaemia. This scoping review is reported according to the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Extension for Scoping Reviews Checklist" [11].We adopted the six-stage methodological framework of scoping review by Arksey and O'Malley [12].

The framework consists of the following steps.

Step 1: Specify the research questions

The following research questions were formulated.

What is the impact of junk food consumption on the development of anaemia among adolescents?

We followed the Population, Concept, Context, and Study design criteria for identifying the studies.

Population

We included adolescents and young adults aged 10 to 25 years. This review encompasses studies on consumption, intake, and dietary patterns, as well as sociodemographic factors associated with anaemia. Additionally, we included studies on risk factors, eating habits, and the impact of fast food and junk food consumption.

Concept

Junk food refers to foods that are high in calories, fats, sugars, and/or salt but low in essential nutrients such as vitamins, minerals, and fibre [13]. These foods are typically highly processed and may include items like fast food, sugary snacks, sodas, and pre-packaged treats [14]. Regular consumption of junk food has been associated with various negative health outcomes, including obesity, cardiovascular diseases, and nutritional deficiencies [15, 16].

Context

The existing literature shows inconsistent findings regarding the relationship between junk food consumption and anaemia. To gain a comprehensive understanding of this issue, we included studies conducted across various global contexts, encompassing low, middle, and high-income countries. These studies were drawn from university, hospital, and community settings, regardless of geographical conditions.

Study designs

We included studies that reported on the relationship between junk food and anaemia. This review encompassed quantitative studies of all designs (Randomized controlled trials, non-randomized controlled trials, observational, cross-sectional, and cohort). We excluded protocols, editorials, social media posts, and magazine reports, as they do not provide substantial information for synthesis. Records without available full texts were also excluded, and only literature published in English was considered.

Step 2: Identify the Relevant Literature

An extensive search was carried out to identify relevant studies. A search strategy was formulated by extracting keywords such as ("Eating"[Mesh] OR "Dietary intake" OR eating OR intake OR Consumption) AND (Junk food OR fast food OR food preserved OR frozen foods OR candy OR canned OR convenience food OR ultra- proceeded foods OR ultra-processed foods) AND (Haemoglobin OR Anaemia OR "Iron deficiency anaemia" OR Anaemia) AND ("Adolescent" [Mesh] OR adolescence OR teen OR teens OR teenager OR youth OR youngsters OR youthful) from the Medical Subject Heading (MeSH) browser [17] and consulting with subject-matter experts (JAN, SCM), as well as reviewing relevant literature. To ensure thorough coverage, six electronic databases Pub-Med (NCBI), CINAHL (EBSCO), Embase (Elsevier), Web of Science (Clarivate), ProQuest, Scopus (Elsevier), and Cochrane Library were searched on 31/07/2024 by SJS, with further validation by JAN. The search strategy utilized Boolean operators like"AND"and"OR"to combine terms. Studies published between January 2014 and July 2024 were included in this review. A detailed search strategy is provided in Appendix 1.

Step 3: Selection of Studies

The database search results were imported into Rayyan software for analysis. [18]. After removing duplicates, two reviewers (SJS and JAN) independently screened the titles and abstracts of the studies. Any discrepancy between the selection were resolved through a consensus-building process. Following these the same two reviewers (SJS and JAN) independently assessed the full texts. In case of disagreements, it was resolved through discussion and in consultation with Third reviewer (MG). Since this is a scoping review focused on providing an overview of the literature, the quality assessment and risk of bias for the included studies were not conducted,

Step 4: Charting the Data

Five reviewers independently extracted data independently (SJS, JAN, SCM, BSN, MG). The data quality was ensured by crosschecking the extracted data by two reviewers (SJS and EGM). Relevant data on authors, country/region, study designs, objectives, methods, key findings and conclusion on consumption of junk food to anaemia were extracted using a predesigned data extraction form on Microsoft Excel.

Step 5: Collecting, Summarizing, and Reporting Results

The findings were summarized using narrative strategy supported by tables where applicable. The results were presented as authors, study year, aims type of study, Methods, key findings and conclusion. The junk food and consumption (type of junk food, frequency of consumption, quantity consumed) and anaemia indicators like prevalence and risk factors of anaemia and association between junk food and anaemia (Table 1).

Step 6: Stakeholder Consultation

We did not engage in stakeholder consultation in this review due to the consequence of time and financial constraints.

Results

Electronic searches were conducted on PubMed (MED-LINE) (n = 63), Web of Science (Clarivate) (n = 59), CINAHL(EBSCO) (n = 230), EMBASE (Elsevier) (n = 527), Scopus (n = 841), ProQuest (n = 1123), Of the 2843 records retrieved, 376 duplicates were removed using Rayyan. Further, 2467 articles were screened for Title-Abstract, and 146 articles, 20 were included for analysis, and others were excluded due to wrong publication type (n = 48) and wrong outcome (n = 8). The PRISMA flow diagram is presented in Fig. 1.Appendix 2 presents a list of records excluded during the full-text stage.

Characteristics of Included Studies Study settings

Four studies were conducted in Indonesia [19–22], five studies were conducted in India [23–27], five studies were conducted in Pakistan [28–32], and one study each was conducted in China [33], Mexico [34], Palestine [35], Taiwan [36], UAE [37] and South Korea [38].

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Author name & year	Aim	Study design	Country	Sample size and Age Da	ata collection methods	Key findings	Conclusion
Batool Zaira, Aziz Karim Saadiya, Begum Amna, 2017	To investigate the fre- quency of anaemia and lits socioeconomic and dietary determinants among adolescent girls	Cross sectional	Pakistan (Karachi)	N = 497 in 13-18 qc Years eqc C II foi to to a r A A A A A A A A A A A A A A A A A A A	terview method using lestionnaire on socio- conomic, dietary, d demographic profiles inical examination rsigns of anaemia as conducted aemoglobin estimation as performed using portable analyser dietary recall was col- cted using a question- tic talored for the study, hich comprised alily, da weekly basis nit realored for the study, da weekly basis and posed ques- ons regarding the qual- r of food consumed a a weekly basis thropometric essurement was done e BMI	36.5% participants were anaemic with haemoglo- bin levels below 11 g/dL Anaemia was significantly associated with lower acoeconomic status, parental education, and dietary intake Anaemic girls had signifi- cantly lower consumption of eggs, milk, spinach, green leafy vegetables, and chocolate/candies compared to non-anae- mic girls	Improving socioeconomic conditions and implement- ing dietary interventions that promote iron-rich foods are crucial for reducing the prevalence of anaemia among adolescent girls in rural Pakistan
2022 2022	To explore the association between dietary pat- terns and explore, their association with aneemia among rural children	Cross sectional	China	N = 1476 TF 9-16 years of Bbys789 pt Girls689 an Fic for arr Nu Nu Nu Si Si Si Si Si Si Si Si Si Si Si Si Si	re survey comprised a questionnaire survey, ysical examination, dlaboratory examina- non analysis identified cor analysis identified tor analysis identified and referary patterns ith anaemia risk mong children in rural eas assed on harmoglobin assed on harmoglobin assed on harmoglobin assed on harmoglobin assed on harmoglobin assed on harmoglobin etary patterns were ference and growth tardation anstructed using phinci- al component analysis of factor rotation	A fast-food consumption pattern was associated with an increased risk of anaemia in children (PR = 1.76.7), particularly in girls after menarche and those who were underweight A dietary pattern rich in meat and eggs was linked to a lower risk of anaemia in children (PR = 0.498) Dietary patterns significantly impacted the prevalence of child- hood anaemia in rural areas Anaemia prevalence was 10.4% higher in girls compared to boys	Fast food consump- tion has been identified as a contributing factor to the risk of anaemia in children, while a diet rich in meat and eggs has shown protective effects, particularly in those entering puberty. The findings of this study can be used to develop evidence- used to develop evidence- used to develop evidence- tions to address anaemia in children

Table 1 (continued)							
Author name & year	Aim	Study design	Country	Sample size and Age	Data collection methods	Key findings	Conclusion
Guadalupe Arli, et al 2006	To describe the die- tary patterns (DP) and to examine its asso- ciation with malnutrition indicators	Cross-sectional	Mexico Urban and rural areas	N = 738 12–19 yea Boys: 12–15 years, 16–1 years Boys—4,57 Girls—2,22	80 This study used data Is from the National Health (9 and Nutrition Survey (ENSANUT-2006) Principal component analysis derived four analysis derived four analysis derived four analysis derived four analysis derived four associated with nutritional status using prevalence atio Seven-day FFQ with 101 food items for dietary data collection Anthropometric tech- niques for measuring weight and height Haemoglobin concentra- tions adjusted for residen- tial altitude	Among children with anaemia, approxi- mately 30% were over- weight or obese Adolescents with higher adherence to the West- ern dietary pattern had a greater prevalence of overweight and obe- sity (PR: 1.15, 95% CI: 1.08-1.21) A higher prevalence of anaemia was observed among those follow- ing the Western dietary pattern (PR: 1.18, 95% CI: 1.03-1.35) 1.03-1.35) and breakfast-type dietary pattern was inversely associated with anaemia in younger adolescents	The Western dietary pattern was positively associated with both obesity and anae- mia in adolescents Nutritional guidance should focus on addressing all forms of malnutrition Adolescence is a critical period for shaping long- term health and dietary habits, emphasizing the need for early interven- tion and education
Akhtar Naveed, Zareen Humaira, Sarmad Rubina 2018	To assess the dietary habits, nutritional status and their association among female medical students	Cross-sectional descrip- tive study	Pakistan (Medical college of Lahore)	N = 11 19-21 yea	4 Structured question- is naire used to collect data on dietary habits Haemoglobin levels were tested using Sysmex Mid upper arm circumfer- ence (MUAC) was meas- ured with a measuring tape Body mass index (BMI) was measured using a weighing machine	36.8% of participants were underweight, and 36% were anaemic 94.7% preferred tradi- tional food, and 73.3% consumed braskfast daily 64% regularly consumed fast/junk food, while 71.1% are meat at least three times per week fast inteed nutritional sta- tus, with skipping break- fast linked to anaemia A positive association was found between eat- ing habits and haemoglo- bin levels (p = 0.001) Regular breakfast intake with BMI and MLAC (p = 0.003) and overall nutritional status (p = 0.003)	Eating habits significantly impact nutritional status, independent of socio- tics. Poor eating habits are associated with anaemia, and skipping breakfast con- tributes to malnutrition

Table 1 (continued)	_						
Author name & year	Aim	Study design	Country	Sample size and Age	Data collection methods	Key findings	Conclusion
Marwan Jalambo et al. 2015–2016	Determine the prevalence and identify the risk fac- tors associated with anaemia, iron deficiency, and iron-deficiency anaemia	Cross-sectional descrip- tive study	Palestine (Gaza Strip)	Z = 3 -19 y cs.	30 Data was collected ars through Three types of questionnaires: FFQ, sociodemographic, sedentary behaviour and physical activity Food frequency question- naire (FFQ) was utilized for dietary assessment Sociodemographic questionnaires were administered to gather background information Questionnaires were administered to gather behaviour and physical activity behaviour and physical activity behaviour and physical activity activity behaviour and physical activity behaviour and bhysical activity behaviour and bhysical activity activity behaviour and bhysical activity a	Anaemia was present in 35.8% of female ado- lescents, iron deficiency (ID) in 40.3%, and iron deficiency anaemia were in 26.0% ID and anaemia were nor significantly associ- ated with physical activity (P < 0.05) ID was linked to poor dietary habits, such as skipping breakfast and frequent junk food consumption IDA was associated with low fruit and vegeta- adolescents Mother's education was associated with ID but not with other socio- demographic factors Reduced meat intake of anaemia (DR = 0.95, 95% CI. 0.92-0.96, P < 0.001) Anaemia in female ado- lescents was associated mith lower intake of meat, mith lower intake of meat, mith power intake of meat,	A significant association was found between iron deficiency (ID), anaemia, and iron deficiency anaemia (IDA) and dietary behav- iours, including skipping breaktast and consuming breaktast and consuming particularly beverages such as soft drinks, artificial juices, coffee, and tea Additionally, increased intake of milk and legumes was linked to a higher risk of ID and IDA in these demographics

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Author name & year	Aim	Study design	Country	Sample size and Age Da	ata collection methods	Key findings	Conclusion
2022 2022	The purpose of this study was to analyse the rela- tionship between diet pattern and the incidence of anaemia in teenage girls	Cross sectional	Indonesia	N = 98 Fo to Ha Var gito gito ad	od frequency ques- imaire model used assess diet patterns iemometer and obser- tion sheet are used determine haemo- bin levels and record ditional relevant data	The overall prevalence of anaemia in Indonesia was 21.7%, with rates of 26.4% among ado- lescents and 50-60% among young women 88.8% of participants had poor eating habits, while only 11.2% followed a good dietary pattern 58.2% of individuals were not anaemia. A significant negative correlation was observed between dietary patterns and anaemia (r =-0.302, p = 0.003)	In appropriate eating patterns can contribute to an aemia, posing signifi- cant health risks for teenag- ers. To prevent anaemia, adolescents should reduce fast food consumption, adopt a nutritious diet rich in fruits and veg- tich in fruits and veg- rich in fruits and aware- ness of health care. These measures can help reduce the risk of anaemia and sup- port overall well-being during this crucial develop- mental stage
Gultom Yohana, Aritonang Evawany 2020	Correlate nutrition knowl- edge and eating pattern with anemia incidence in female teenagers	Descriptive study with cross-sectional design	Indonesia	N = 100 De lev qu for for for for for for for for ha	ta obtained rough haemoglobin ele examination, estionnaires, food recall ms ms ranination arnination arnination arnination extowledge and eating bits assessing the dietary ake al frequency form tract eating patterns	The prevalence of anae- mia among female reenagers in the rural area is 58% Inadequate iron intake increased the risk of anae- mia by eight times The majority of female teenagers had sufficient protein intake	Female teenagers with insufficient iron intake are eight times more likely to develop anaemia com- pared to those with ade- quate intake Anaemia can result from multiple nutrient deficiencies, and infectious diseases may further hinder from and a supportive environment is essential for promoting healthy physical and psychological development during ado- lescence
Parveen Nisha, Rani Seema, John Neha, 2018	To assess the prevalence of anaemia and iden- tify dietary practices among adolescent girls	Descriptive survey	India	N = 100 Ar Girls- 100 usi Adolescents aged 11–17 an years were included mr in the study be thr thr ing	ing flow cytometry d the SLS-haemoglobin ethod e data on balanced diet haviour as collected cough a structured estionnaire and record- g sheets	66% of adolescents were anaemic, with 31% mild and 25% moderate. 10% were classified as severely anaemic A Significant relationship was found between nae- mic status and the fre- quency of eating junk food	The high prevalence of anaemia among adoles- cents necessitates emphasis on iron and folic acid supplementation, iron-rich food intake, health educa- tion on personal hygiene, and periodic deworming to reduce the burden of anaemia among adoles- cent girls

Author name & year Aim							
		Study design	Country	Sample size and Age	Data collection methods	Key findings	Conclusion
Singh Parul, Tiwari Har-To esti ish C, Sampriya Arushi, lence c Srivastava among Arun K Srivastava Dhiren-lescent dra K. 2020 thiren-lise soc filte soc filte soc and mu	imate the preva- imate the preva- g school going ado- it girls and to study ic factors ciodemographic s, dietary factors henstrual factors	Cross sectional study	India	N = 4 Gilds- 4 10-19 ye	30 Pre-phrased question- 30 naire was used for data ars collection Interview methods were used to collect the data regarding the sociodemo- graphic variables, dietary variables, and menstrua- tion-related variables tion-related variables tion-related variables assessment of the study participants involved the measurement of height, weight, and body mass index (BMI) calculation of BMI, Height was measured using a portable stadi- ometer BMI calculation and hae- moglobin estimation using portable instru- ments	Anaemia was observed in 61.39% of school- going adolescent girls, with a higher prevalence among obese individuals (6666%) Risk factors for anaemia included age, low socio- economic status, dietary habits (intake of junk food), and menorrhagia A Strong association found between IFA intake and anaemia prevalence A Strong association found between IFA intake and anaemia prevalence of strong association found between BMI and haemo- globin levels in the study group and occupation, birth parental integu- larities, polymenorrhea, and dysmenorrhea were	Anaemia is highly prevalent (61.39%) among adoles- cent girls. Significant risk factors include age, living in a nuclear family, and low socio-economic status. Ing to anaemia include low intake of citrus fruits and green leafy vegetables, along with high consump- tion of junk food

Author name & year	Aim	Study design	Country	Sample size and Age Data collection methods	Key findings	Conclusion
2015 2015	Investigate dietary pat- terns, lifestyle, nutritional status, and anaemia related biomarkers among adults	Observational study	Taiwan	N = 118,924 Self-reported question- 20–45 years naire for information Boys-43.055 on sociodemographic Girls-75,869 data, lifestyles, medical history, and dietary habits Body weight status was defined by using BMI criteria in Tai- wern masured by using an auto-anthropometer. Weight status was defined by using BMI criteria in Tai- wan, and waist circumfer- ence was used to define central obesity Biochemical data, includ- ing anaemia related biomarkers such as hae- moglobin, haematocrit, and RBC were done. The level of CRP was measured using an auto-analyser. Anaemia was classified biomarkers such as hee- moglobin, haematocrit, and RBC were done. The level of CRP was measured using an auto-analyser. Anaemia was classified bietary pattern derived by Reduced Rank Regres- sion method associated with aneemia risk Dermographic and lifestyle variables analysed for anaemia and bio- markers	A High dietary pattern (processed foods, and sugary beverages) increased the risk of anae- mia by 59% Alcohol consumption (46%) and abnormal weight status, includ- ing underweight (23%), overweight (23%), overw	Adherence to the anae- mia-inflammation dietary pattern is associ- ated with an increased risk of anaemia in Taiwanese adults. Additionally, abnormal weight status and alcohed consumption are correlated with a higher risk of developing anaemia
2020 2020	To study the magnitude of anaemia in young females and its associa- tion with diet pattern	Cross sectional study	India	N = 100 Recorded demographic Girls-100 details, dietary pattems, 18–40 years and haematoo parameters Datameters logical parameters using automated cell counter and blood smears Categorized anaemia severity based on WHO criteria for haemoglobin levels	62% of participants were anaemic, with a mean age was 26.52 years Among the anaemic participants, 44% had mild anaemia, 16% had moderate, and 2% had severe anaemia 47% of those who did not consume green leafy vegetables had mild to moderate anaemia 25% of individuals who drank tea or coffee drank tea or c	Iron deficiency anaemia is common among young females, especially those with poor dietary habits. Health education on proper dietary practices is essential for preventing nutritional anaemia in this group

Table 1 (continued)

Table 1 (continued	(
Author name & year	Aim	Study design	Country	Sample size and Age Da	ata collection methods	Key findings	Conclusion
Dinar, Putri Rahmawati, Dono Indarto, Hanim Diffah 2020	The study aimed to inves- tigate the correlation of fast food consumption and snacking with hemo- globin (Hb) levels in female adolescents	Cross sectional study	Indonesia	N = 117 Bo Girls - 117 mt 15-18 years sci ing thr Ha Ha tes	vdy weight and height easured using digital ales and microtoice a data collected rough Food Prequency uestionnaire (FFQ) emoglobin levels sted using haematol- by analyzer at Clinical boratories	Fast food consumption was negatively correlated with Haemoglobin levels ($r = -3.47$; $p = 0.001$) Snacking showed no significant correlation with Haemoglobin levels ($r = -1.44$; $p = 0.152$) The prevalence of anae- mia among female adolescents was 17.1%	Fast food consumption negatively impacts hae- moglobin levels in female adolescents. Snacking does not show a significant cor- relation with haemoglobin levels. The R-square value indicates that dietary factors contribute 18.6% to haemo- globin levels
	To evaluate the changing food pattern in adoles- cents and its impact on health	Observational study	India	N =450 An 10–19 years we Ma Thr thr thr Co Qu Qu An A A A A A A A A A A A A A A A A A A	uthropometric data as collected for Body ass Index calculation statled diet his- ry was obtained rough questionnaires. react alsing structured sessed using structured restions onsumption of junk food remoglobin concentra- nons were analyzed using hil's hæmoglobin terer cioeconomic class rived using Modified asad classification	23.5% of adolescents con- sumed junk food twice or more per week 50% of adolescents from high socioeconomic backgrounds were at risk of overweight and obesity Junk food consumption contributed to a 27.4% risk of being overweight and a 1.9% risk of obesity and a 1.9% risk of obesity and 3.5% of males and 73.5% of adolescents who consumed junk food at least twice a week were aneamic Skipping breakfast twice weekly resulted in 96.6% of adolescents being anaemic	Junk food consumption contributes to obesity, diabetes, hypertension, and coronary diseases. Reducing junk food intrake can minimize health risks in adolescents

Table 1 (continued)							
Author name & year	Aim	Study design	Country	Sample size and Age	Data collection methods	Key findings	Conclusion
Chaudhuri K Partha, Chaudhuri K Partha, Chaudhary Anil, 2017	To study the correlation between dietary habits and anemia among adolescent girls	Analytical cross-sectional epidemiological study	India	N = 30 10-19 year	0 Questionnaire-cum- s' interview technique used for primary data collection Haematological param- eters obtained using auto- mated hematology cell counter and microscopy Dietary habits assessed through last 24 h food intake	82% participants were anaemic, with 34% having mild anaemia Despite the high anaemai rate, 91.7% of girls had a normal BMI Anaemia was more common in vegetar- ians and was associated with a rice-based diet with a rice-based diet compared to non-veg- terians Increased anaemia preva- lence was linked to low into and vitamin C intake There was a significant association between con- suming tea or coffee after meals and the occur-	Adolescent girls are at a heightened risk of anemia, with severity increasing from early to late adolescence. Vegetarians, particularly those on pre- dominantly rice-based diets, are more susceptible to ane- mia than non-vegetarians. Additionally, consuming tea or coffee after meals significantly correlates with reduced iron absorp- tion, thereby increasing anemia risk
Yahya Sheherbano, etal, 2022	To find iron deficiency anemia and the relation- ship between people who consumed junk food	Observational survey- based study	Pakistan	N = 20 Boys -5 Girls -15 18-35 year	O Data was gathered O via a questionnaire O The questionnaire The questionnaire information, nutitional status, and knowledge regarding anaemia A food frequency ques- tionnaire checklist were used, which comprised 25 frequently consumed fast food items Measurements of Height and weight were con- ducted to determine Body Mass Index (BMI) Haemoglobin levels were analysed using hematol- ogy aanalyser	Anaemia awareness: 42.5% aware, 57.5% unaware 91.17% anaemic patients consumed junk food daity 85% of participants were anaemic, whereas 15% had normal haemoglobin BMI: 11.76% were under- weight, 17.65% were anal weight, 17.65% were overweight, and 17.65% were overweight, and 17.65% were obese A positive correla- tion was observed between junk food con- sumption and anaemia	High consumption of junk food is positively correlated with an increased risk of anaemia. Implement- ing awareness programs and counseling sessions has been shown to signifi- cantly improve knowledge and behaviors related and behaviors related and behaviors related and behaviors related and behaviors related with targeted educational interventions, is essential for effectively reducing anaemia cases

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Author name & year	Aim	Study design	Country	Sample size and Age Data collection methods	Key findings	Conclusion
Benash Altaf, et.al, 2017	The aim is to deter- mine the frequency of anemia and to find its association with junk food among medical students	Cross-sectional study	Pakistan	N = 112 Data was collected Boys—58 through pre-designed Girls—54 proforma 18–25 years Data collected on age, BMI, junk food consump- tion, and dietary habits Dietary habits were also recorded on pre- designed proforma Haermoglobin levels checked using Sahil's method and automated analyser to assess anaemia	 49.1% of students consumed junk food: 69.1% were anaemic A significant negative association was found between junk food consumption and hemoglobin levels (P value 0.009*) Further Regression analysis confirmed a negative association between junk food intake and haemoglobin levels globin levels 	Anaemia is more prevalent among girls consum- ing junk food than boys, highlighting the significant negative association of junk food with anaemia
Jeong, Jaehoon, Cho, Younghoon In-Young Cho, Joonho Ahn, etal 2022	To Investigate obesity's link to anemia in ado- lescents	Cross-sectional study	South Korea	N = 185.731 Data collected Boys - 12.697 from the 2007 - 2019 Korea Girls- 173,033 National Health and Nutri- 10–21 years tion Examination Survey Health interviews were conducted by trained medical staff Health examinations and height and weight were performed in mobile examination centres Anaemia was measured according to WHO criteria	The risk of Anaemia i is higher in obese early adolescents (OR 2.88, 95% Cl 1.20–6.95) No significant relation- ship between obe- sity and anaemia was observed in adolescents overall, except in early ado- lescents aged 10–13, where obesity was linked to an increased risk of anaemia	Anaemia is a treatable condition that requires special attention in obese early adolescents, as they are at an increased risk
Ayub Hina et al. 2023	To evaluate dietary factors contributing to anemia among girls	cross-sectional	Pakistan	N = 130 Data on socioeconomic, Girls – 130 demographic, and dietary Girls – 130 demographic, and dietary 12–16 years factors collected via a questionnaire A Self-developed questionnaire was used for dietary information collection (i.e., dietary habits, food intake, veg- etarian or non-vegetarian dietary patterns, con- sumption of junk food) The cyanmethemoglobin method was used for Hb estimation	82% of adolescent girls in urban and rural areas were anaemic (p = 0.001) Among rural girls, 43.84% had mild anaemia, and 13% had severe anaemia 70.7% of girls were under- weight, 93% followed a mixed dietary pattern menstruation, 87.6% experienced men- struation lasting more than 5 days	Anaemia is a significant health issue, among girls especially in rural areas, where awareness of iron- rich diets is of then limited. To effectively address anaemia among adolescents, it is essential to prepare the public health system to implement programs that raise awareness and promote the consump- tion of iron-rich foods

Table 1 (continued)							
Author name & year	Aim	Study design	Country	Sample size and Age	Data collection methods	Key findings	Conclusion
Sabbah, Haleama Al 2020	The present study assessed the asso- ciations of overweight, obesity and anaemia with selected lifestyle factors, total body fat and abdominal obesity among female university students	Cross-sectional study	United Arab Emirates	Females - 2	51 A self-reported question- 51 an aire was utilized for data collection The questionnaire included items on obesity, and lifestyle Blood samples were col- lected using finger pricks Hb levels were measured with a Hemocue analyser for Hb level measurement Associations of lifestyle factors, total body fat, and abdominal obesity examined	29.3% of participants were classified as over- weight or obese 18.1% of participants were diagnosed with anaemia 8.5% of participants exhibited abdominal obesity Total body fat percentage was highest among stu- dents with anaemia	The prevalence of anaemia and obesity/overweight among female univer- sity students highlights the need for health promotion and nutritional education programs. Implementing such initia- tives is essential to enhance the overal health and well- being of this population
Sari P, Bestari A, Astuti, R, Bestari D 2019	To determine the preva- lence of anemia and its correlation between ane- mia and nutritional status among adolescent girls	Community-based Cross- sectional survey	Indonesia	N = 6 Girls—5 10–19 yea	22 Nutritional status is clas- 22 sified by BMI categories is according to WHO standards Haemoglobin concentra- tion determined by cyan- methemoglobin method 24 h of dietary intake, through interview methods	26.09% of adolescent girls had anaemia, 73.91% had normal haemoglobin levels No significant correlation between nutritional status and amemia armong ado- lescent girls Anaemia linked to iron deficiency, dietary habits, and demographic factors	Nutritional status did not significantly contribute to anaemia in adolescent girls, as various factors can cause anaemia, such as dietary iron deficiency and sociodemographic characteristics



Fig. 1 A PRISMA flowchart of the study selection process

Study Designs

The data for this review were collated through cross-sectional studies and observational studies. However, there were few Randomized and non-randomized Controlled trials on this topic, and the authors had to exclude those studies since they did not meet the inclusion criteria. This review included data from cross-sectional observational studies. The characteristics of the included studies are detailed in Table 1.

The findings of our review is categorised as impact of junk foods on anaemia, types of the junk food taken, the frequency and consumption of junk food, other risk factors related to anaemia and additional findings from the studies.

Impact of junk foods on anaemia

Numerous studies have demonstrated a link between the consumption of convenience foods, fast food, snacks, and beverages with a prevalence of anaemia, particularly among adolescents undergoing puberty [33]. A Western diet, which is high in energy, fat, and sugar, has been found to have a stronger association with anaemia compared to non-traditional breakfasts, which were inversely related to anaemia [34]. Another study highlighted a significant association (p < 0.05) between iron deficiency (ID), anaemia, iron deficiency anaemia (IDA), and dietary habits such as skipping breakfast and consuming large amounts of junk food. [35]. One study showed that there is a relationship between diet pattern and the incidence

of anaemia, lower a person's diet, higher the category of anaemia experienced also it was found that 88% of adolescent were of Poor eating patterns, they preferred it as fast food because it is easily available fast processing and was waiting time was less [19]. Another study revealed that female teenagers with insufficient iron intake were eight times more likely to develop anaemia compared to those with adequate iron intake. [21]. Additionally, in one study, a positive link was found between poor eating habits, specifically the frequent consumption of unhealthy, junk foods and anaemia, with most adolescents showing a preference for junk and fast foods. [29]. Also, another study revealed a positive correlation between intake of junk food and the risk of anaemia, which showed that higher levels of junk food consumption are linked to an increased likelihood of anaemia, while lower levels of consumption correspond to a reduced risk of the condition. [30] study also found that a significant portion of junk food consumers, specifically 69.1%, were found to be anaemic, with their haemoglobin levels notably lower compared to those who did not consume junk food [31]. Studies have demonstrated that a large proportion of adolescents regularly indulge in junk food at school, leading to a reduced consumption of eggs and fish [32] (Table 1).

Type of junk foods

In our review, we found that the types of junk foods most frequently consumed by the adolescents included fried chicken, chicken soup, martabak, noodles, dumplings, fried foods, sempol, cilok, and pentol, with daily consumption being common. [19] Studies indicates that the snacks most frequently consumed by teenagers consist of meatballs, chicken noodles, fried foods, and donuts [21, 29] Additionally, a significant number of adolescents habitually consumed instant noodles, fried rice, and fried noodles [22], along with chocolate biscuits and candies [28]. One study identified dietary patterns related to anaemia and inflammation, characterized by a high intake of eggs, meat, organ meats, rice or flour products, fried rice or flour, sugary beverages, fried foods, and processed foods [36] A study observed that adolescents frequently consumed a Western-type diet characterized by industrialized sweet drinks, salty snacks, sandwiches, charcuterie [34]. (Table 1).

Frequency of consumption of junk food and anaemia

Most adolescents consumed junk food daily, while fruits and vegetables were typically eaten only once a week or, for some, just 3–6 times a month [19]. A significant portion, 71.1%, consumed meat and meat products three times a week. [29]. One study found a significant relationship between anaemic status and their frequency of fast food consumption ($p = 0.04^*$) [25]. Also in one study, the frequency of fast food consumption was inversely related to haemoglobin levels in female adolescents (r = -2.07; p = 0.025), indicating that the more often they consumed fast food, the lower the Hb levels tended to be [22]. A study has revealed a robust association between the consumption of junk food and anaemia in adolescents. Specifically, it was found that 81.5% of participants who consumed junk food on a bi-weekly basis and 96.6% of those who frequently skipped breakfast were affected with anaemia. [23]. Many adolescents had a frequent habit of consuming junk food [24] (Table 1).

Risk factors

The highest risk for anaemia included being underweight [29, 30, 32, 33] with a higher prevalence observed in women compared to men. Other significant factors were age, gender, [36] parental education level [33], obesity [19], specifically those with obesity, central obesity, or who were underweight had an increased risk of anaemia [36]. Additionally studies such as nuclear family, high intake of junk foods, low intake of milk, eggs, green leafy vegetables [28], citrus fruits, lack of folic acid intake and menorrhagia [26], and current alcohol consumption, were associated with higher risk of anaemia [30]. Obesity was notably linked to a greater risk of anaemia, particularly in early adolescents. [38], Adolescents consuming Junk food twice or more in a week were more over weight and at risk of overweight as compared to them who consumed junk food only once or rarely in a week. [23]. iron deficiency was also a significant risk factors for anaemia [36] (Table 1).

Additional findings

Sociodemographic characteristics: Most of the studies in our review found that lower socio-economic background are significantly associated with anaemia (p < 0.01), [28] also study emphasized on other factors like parental education (p = 0.022), especially mothers education [35] unemployment [28], in one study it was evident that adolescents from higher socioeconomic class are more prone to overweight and obesity. Due to greater financial means to frequently purchase junk food. This increased the access to junk food can lead to overweight and obesity. [23]. One study have highlighted that anaemia, along with overweight, obesity and anaemia were more prevalent among female students who perceived their families having a moderate economic status. [37].

Dietary patterns

Dietary patterns play a significant role in the prevalence of anaemia, particularly among adolescents low consumption of infrequent consumption of eggs, milk, green leafy vegetables such as spinach, and even indulgences chocolates, candies, biscuits, cakes have associated with increased risk of anaemia. [28] whereas in one study shows that food patterns like meat and eggs have been to be protective against anaemia. Studies have highlighted that decrease in meat consumption is likely to lead to anaemia, and diet lacking milk and beverages is significantly associated with anaemia [35]. Additionally study also showed that reduced intake of vegetable, fruit and meat is more likely to result in iron deficiency anaemia [35]. One study showed that dietary patterns characterized by high intakes of eggs, meat, organ meats, rice or flour products, fried foods, sugary beverages, and processed foods significantly increased the risk of anaemia. This pattern is linked with decreased levels of haemoglobin, haematocrit, and red blood cells, while it elevates white blood cells and C-reactive protein levels. [36]. Moreover, in one study specific dietary habits have been closely associated with varying degrees of anaemia. for instance women who did not consume green leafy vegetables had mild to moderate anaemia, women who drank tea or coffee immediately after meal had mild anaemia and women eating junk foods and less fruit intake had mild to moderate anaemia [27] A study found a strong correlation between skipping breakfast and anaemia among adolescents. Those who skipped breakfast twice or more per week were significantly more likely to be anaemic compared to those who skipped breakfast only once or rarely in a week. This relationship highlights the impact of breakfast habits on the prevalence of anaemia. [23], In one study. Anaemia appears to be more prevalent among vegetarians than non-vegetarians, particularly among those with a predominantly rice-based diet ('r' =0.871). There was increased association on consumption of tea and coffee post- meals (r = 0.892). [24] and the occurrence of anaemia. Furthermore, western patterns of diet have been linked with stunting. [34] in one studies showed that skipped meals, such as breakfast, or lunch are more likely to lead to anaemia. [35].

Lifestyle and Physical activity: One study showed the relationship between alcohol intake and a lack of physical was positively correlated with the occurrence of anaemia. Factors such as age, gender, hypertension, and both smoking and alcohol use, which were significantly related to anaemia. [36] A study revealed a larger number of patient with iron deficiency anaemia had moderate physical activity. [30].

Obesity: The prevalence of obesity was high among the adolescent who consumed western pattern of diet. Both Western and plant-based patterns were linked to overweight and obesity as well as at least one indicator of undernutrition [34]. Additionally, the consumption of fast food and the habit of skipping breakfast increased as adolescents transitioned into adulthood, with these dietary behaviours being associated with greater weight gain during this period. [23] In one study approximately one-third of female university students were identified as overweight or obese, with a prevalence of having abdominal obesity and anaemia. The Majority of these students reported irregular eating patterns, especially among those who were obese or overweight. Also the study found that both the Western and plant-based patterns were simultaneously associated with overweight–obesity and at least one indicator of undernutrition. [34].

Discussion

The present study aimed to explore the impact of junk food on the prevalence, severity of anaemia, particularly among adolescents. Our findings reveal a significant association between frequent consumption of junk food and an increased risk of anaemia, as evidenced by lower haemoglobin levels and a higher incidence of iron deficiency. Also some additional findings like other factors role of socio-demographic factors, dietary patterns, obesity, lifestyle and physical activity were linked with anaemia.

Impact of junk food on anaemia

Numerous studies have found that there is a link between junk food consumption and anaemia one of the most common type of anaemia is iron deficiency anaemia and megaloblastic anaemia in young population [39]. Most of the adolescents prefer western type of diet [40] which increases the incidence of anaemia. A systematic review seven key topics on nutrient adequacy, fruit and vegetable consumption, water and beverage intake, sodium (Na) intake, breakfast habits, snacking frequency, and Western fast food consumption revealed the following adolescents tend to consume insufficient amounts of protein, fruits, and vegetables, while their intake of sodium and Western fast food is excessively high. [41]. The study found a significant correlation between breakfast habits and the incidence of anaemia among adolescents. Results showed that students who skip breakfast have a one or two -times higher risk of developing anaemia compared to those who regularly eat breakfast. Statistical analysis revealed that (p = 0.036) a significant relationship between skipping breakfast and the increased risk of anaemia. [42]. Whereas in this review skipping breakfast were directly related to anaemia.

Junk food typically contains high levels of trans fats, salt, and sugar, but is low in essential nutrients, contributing to poor nutritional outcomes usually Today, many foods are made with extra sugar and fat, making them even less healthy [43]. Thus consumption of junk food are high among adolescents [44]. These results align with the hypothesis that diets high in processed foods, which are typically low in essential nutrients like iron, contribute to the development of anaemia. A study conducted have shown that the iron content in fried Tempe and noodle showed a significant difference with p > 0.05, while the iron content in fried chicken in the two school groups did not show different results. However, the percentage contribution of iron to the Nutrition Adequacy Rate (RDA) was minimal [45], also exposure to junk food related content are linked to heightened sensations of hunger, stress, sadness, and fatigue, along with an increased desire for salty, savoury, and fatty foods [46]. Most of junk foods consumed by the adolescents are soups, noodles, fried foods, meat balls sweet drinks, salty snacks, sandwiches. These findings are similar to a study where fast food consumed frequently by 36% of individuals, 12% reported regular consumption of sugar-sweetened beverages. The items most often consumed included salty snacks (77%), and regular soda (77%), [47] and also most of the adolescent they consumed inadequate fruits and vegetables [48] which also a similar findings in this review.

The findings of this review suggest a significant association between the frequency of fast-food consumption and the prevalence of anaemia among adolescents. The study indicate that a majority of adolescents consume junk food daily, which correlates with lower haemoglobin levels. Interestingly, while meat and meat products were typically consumed around three times per week, the intake of junk food had a more pronounced negative impact on haemoglobin levels. Adolescents with higher junk food consumption tended to have lower haemoglobin levels, increasing their risk of anaemia.

Moreover, the review highlights that adolescent who frequently skipped breakfast was particularly vulnerable to anaemia. This aligns with other studies that observed similar trends, where the frequency of junk food consumption less than three times a week or up to three times a week was linked to an increased risk of anaemia [49]. Furthermore, additional research supports these findings, showing that girls who routinely skipped meals, especially breakfast, were more likely to develop anaemia [50]. These patterns underscore the critical role of dietary habits in adolescent health, particularly in relation to anaemia prevention.

In addition to the observed dietary patterns, there are important biological mechanisms by which junk food consumption contributes to iron deficiency anaemia. Diets dominated by energy-dense, nutrient-poor foods lack essential micronutrients such as vitamin *C*, which facilitates non-heme iron absorption, and instead contain inhibitors like phytates, calcium, and polyphenols that hinder iron bioavailability. Additionally, frequent consumption of high-fat, sugary, and processed foods has been linked to low-grade systemic inflammation, which can stimulate the hepatic synthesis of hepcidin-a regulatory hormone that inhibits intestinal iron absorption and iron release from macrophages and liver stores [36] Elevated hepcidin levels result in functional iron deficiency, even when total body iron stores may appear sufficient. Furthermore, junk foods often displace iron-rich whole foods such as meats, legumes, eggs, and green leafy vegetables [35, 36]. One study in this review also observed that dietary patterns high in fried and processed foods, sugary beverages, and refined carbohydrates were associated with reduced haemoglobin, haematocrit, and red blood cell levels, and increased levels of C-reactive protein—a marker of inflammation [36]. These biological interactions underscore the importance of not only reducing junk food consumption but also promoting balanced diets to prevent and manage anaemia, particularly among adolescents.

Role of Socio-demographic factors

Also, some of the additional findings of this reviews are age, gender as critical factors. Specifically, being females and younger age is consistently associated with higher anaemia risk. This is supported by findings that girls, particularly those who menstruate, are at increased risk. [2].Key risk factors identified include being underweight, particularly in girls, with higher prevalence among women compared to men. Obesity including central obesity and being underweight, also significantly increases the risk of anaemia. Other notable factors include age, gender, parental education level, and iron deficiency. Similar factors were found in other studies [1, 2].

Dietary Patterns and Nutrient Deficiency

Dietary practices play a crucial role, with high junk food consumption and low intake of nutritious foods like milk, eggs, green leafy vegetables, and citrus fruits contributing to anaemia risk. A study finding showed that the daily intake of nutritious foods among adolescent girls was low, with only 16% consuming dairy, 46% eating meats, 44% eating fruits, and 37% eating vegetables. In contrast, energy-dense, nutrient-poor options like sweet snacks, salty snacks, fast foods, and sugar-sweetened beverages were consumed four to six times per week by girls, respectively. Additionally, 40% of the girls reported that they skipped breakfast. Thus many studies have shown that dietary pattern plays an important role in developing anaemia where similar findings have been found in this review [51].

Socioeconomic and Educational Influence

Also, Socioeconomic status and educational level are indirect but influential risk factors, as lower socioeconomic status and educational attainment are associated with a higher risk of anemia risk [28, 35, 37].

Strengths and Limitations

There is a dearth of synthesized literature on the consumption of junk on anaemia. This review may be one of the first to attempt to know how junk foods contribute to the development of anaemia among adolescent girls. These studies on dietary patterns and dietary practices, make their findings highly applicable to everyday scenario. This review covers a broad range of junk foods and their potential impacts on anaemia, providing comprehensive insights into dietary patterns. Various electronic databases have been utilized to facilitate a thorough search of the literature. the studies have been scrutinized in a greater detail to clarify several aspects concerning the consumption of junk foods and it links to anaemia. The study offers insights to practitioners, policymakers, researchers, and adolescent groups. This review has not included qualitative studies in its literature and we acknowledge this as a significant limitation. Some studies use longitudinal designs to track changes in diet and anaemia over time, offering valuable insights into causal relationships. Many studies rely on self-reported dietary data which can be inaccurate due to recall bias or misinterpretation. Most of the studies are cross-sectional designs are often used in research, as they can indicate association; however, they do not establish a causal relationship between junk food consumption and anaemia. Factors like overall diet quality, socioeconomic status, and other health conditions might confound the relationship between junk food consumption and anaemia. Results may not be generalizable to all populations or age groups, particularly if the study sample is specific or limited different studies may define"junk food"and"anaemia"differently, leading to inconsistencies and difficulties in comparing findings across studies. Furthermore, the study did not account for other factors that may influence anaemia, such as genetic predisposition, underlying health conditions, or socioeconomic status. Future research should focus on Randomized Controlled trials and longitudinal studies to better establish the causal relationship between junk food consumption and anaemia. Additionally, studies that investigate the specific components of junk food that contribute to anaemia, as well as the effectiveness of dietary interventions in reducing anaemia risk, would be valuable.

Implications

This study highlights the critical need for more comprehensive research to fully understand the relationship between junk food consumption and anaemia in adolescents. The current evidence suggests a potential link between poor dietary habits, including high intake of fast food and low consumption of nutritious foods like fruits, vegetables, and iron-rich items, and the development of anaemia. Addressing these modifiable risk factors could be essential in developing effective prevention and management strategies for anaemia among adolescents. Moreover, this study aligns with global health priorities, such as Sustainable Development Goal (SDG) 3, which focuses on promoting health and well-being, particularly by addressing adolescent health and preventing anaemia-related complications. Additionally, the findings support broader initiatives aimed at ending hunger, achieving food security, and improving nutrition.

Conclusion

The study concludes that there is emerging evidence suggesting a link between junk food consumption and the prevalence of anaemia among adolescents, particularly in developing countries. While some studies indicate significant associations, others do not, highlighting the need for more comprehensive research to fully understand this relationship. The findings emphasize the importance of addressing modifiable dietary risk factors, such as the intake of fast food and poor eating habits, in the prevention and management of anaemia in adolescents. The mixed results from the analyzed studies indicate that more in-depth research is needed to clarify this relationship. Understanding how dietary habits, particularly the consumption of energy-dense, nutrient-poor foods, contribute to anaemia is crucial for developing targeted interventions. The research highlights the necessity of tackling the dietary risk factors within the framework of comprehensive public health initiatives aimed at decreasing the incidence of anaemia among adolescents and enhancing their overall status. This research supports global health initiatives, particularly Sustainable Development Goal (SDG) 3, which focuses on promoting well-being and addressing adolescent health, as well as efforts to end hunger, achieve food security, and improve nutrition.

Supplementary Information

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Additional file 1.

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Authors' contributions

SJ.S, J.A.N, S.C.M, B.S.N, R.D.J and M.G were involved in the development of the research idea, the review of data extraction and analysis, and drafting and revision of the manuscript. SJ.S, J.A.N, B.S.N, and E.G.M were involved in the search extraction and analysis of data from the papers and the drafting of the manuscript.

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Data availability

Data is provided within the manuscript or supplementary information files.

Declarations

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Consent for publication

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Competing interests

The authors declare no competing interests.

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