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Determinants of iron-rich food deficiency among children under 5 years in sub-Saharan Africa: a comprehensive analysis of Demographic and Health Surveys

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ABSTRACT

Background Iron deficiency is a major public health problem that affects the physical and cognitive development of children under 5 years of age (under-5 children) in sub-Saharan Africa (SSA). However, the factors associated with the limited consumption of iron-rich foods in the region are poorly understood.

Objective This study examined the prevalence and determinants of iron-rich food deficiency among under-5 children in 26 SSA countries.

Design This nationally representative quantitative study employed pooled data from Demographic and Health Surveys conducted between 2010 and 2019.

Methods Representative samples comprising 296 850 under-5 children from the various countries were used. Bivariate and multivariate logistic regression models were used to determine the associations between the lack of iron-rich food uptake and various sociodemographic factors.

Result The overall prevalence of iron-rich food deficiency among the children in the entire sample was 56.75%. The prevalence of iron-rich food deficiency varied widely across the 26 countries, ranging from 42.76% in Congo Democratic Republic to 77.50% in Guinea. Maternal education, particularly primary education (OR 0.62, 95% CI 0.57 to 0.68) and higher education (OR 0.58, 95% CI 0.52 to 0.64), demonstrated a reduced likelihood of iron-rich food deficiency in the sample. Likewise, paternal education, with both primary education (OR 0.69, 95% CI 0.63 to 0.75) and higher education (OR 0.66, 95% CI 0.60 to 0.73) showed decreased odds of iron-rich food deficiency. Postnatal visits contributed significantly to reducing the odds of iron-rich food deficiency (OR 0.90, 95% CI 0.83 to 0.95), along with antenatal visits, which also had a positive impact (OR 0.84, 95% CI 0.74 to 0.95). Finally, residents in rural areas showed slightly higher odds of iron-rich food deficiency (OR 1.12, 95% CI 1.10 to 1.28).

Conclusion Based on the findings, interventions targeting iron-food deficiency in the SSA region should take into strong consideration the key determinants highlighted in this study.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ One strength was that the study used nationally representative data from 26 sub-Saharan African countries, hence promoting a more valid, comprehensive and reliable analysis.
⇒ One limitation was the inability to establish causality among the variables due to its cross-sectional nature.
⇒ Another limitation was the potential impact of differences in data collection timing across countries on the accuracy and precision of assessing deficiencies in iron-rich food intake within the sample.
⇒ Demographic and Health Survey (DHS) data primarily rely on self-reported information which increases the likelihood of social desirability and information recall bias.
⇒ The lack of potential confounding variables, such as cultural factors in the DHS data, represents a significant limitation in understanding the complete array of factors influencing the deficiencies in iron-rich food intake in the sample.

INTRODUCTION

Although iron deficiency is a significant public health concern,[1–3] there is an absence of an international agreement on measuring the iron status of populations, especially, in under-5 children.[4–6] This has led to the common practice of estimating the prevalence of iron deficiency by relying on the prevalence of anaemia, determined through measurements of blood haemoglobin concentration.[4–6] Nevertheless, available estimates from the WHO indicate that approximately 33% of non-pregnant women, 40% of pregnant women and 42% of children worldwide are affected by iron deficiency.[5–7] These statistics highlight the hidden but widespread nature of iron deficiency, especially in children and the need for effective interventions and policies to address this significant public health problem.

Iron deficiency has detrimental effects on the physical and cognitive development of children.[8 9] Evidence indicates that iron deficiency is associated with cognitive impairment, psychomotor disorders and behavioural problems.[10] The most commonly observed cognitive domains impacted by iron deficiency include attention, emotion, intelligence and sensory perceptions.[10] Additionally, iron deficiency has the potential to adversely impact the capacity for learning and acquisition of professional skills.[10] Taken together, iron deficiency has detrimental effects on the physical and cognitive development of under-5 children.

It is widely known that children in sub-Saharan Africa (SSA) face a substantial burden of iron deficiency, posing a significant threat to their well-being.[11] A review paper has indicated that the general occurrence of iron deficiency anaemia among African children, as defined by the WHO, stood at 34%, whereas it reached 52% when considering the estimate adjusted for inflammation and malaria.[11] The review highlights the alarmingly high occurrence rates of iron deficiency in the region, emphasising the urgent need for interventions.

The most practical and viable method for reducing iron deficiency in under-5 children in SSA is by promoting the consumption of iron-rich foods.[12–14] Iron-rich foods are essential dietary sources containing a significant amount of bioavailable iron, a crucial mineral vital for proper bodily functioning and development.[15] These foods hold a pivotal role in preventing iron deficiency, especially among children under 5, and are vital for overall health and well-being.[16] Examples of such iron-rich foods encompass a diverse range of options, including red meat (beef, lamb and pork), poultry (chicken and turkey), fish and seafoods (salmon, tuna, sardines, clams and mussels), legumes (lentils, chickpeas, black beans, kidney beans and soybeans), tofu, fortified cereals, dark leafy greens like spinach, nuts and seeds (pumpkin seeds, sunflower seeds and almonds), dried fruits (raisins, apricots and prunes) and quinoa.[14 17 18]

Despite the recognition of iron deficiency in children as a critical public health issue in SSA, there remains a substantial gap in recognising the prevalence of iron-rich food deficiency and the factors associated with the lack of iron-rich food consumption in this priority population. Previous studies, for instance,[12 19 20] have primarily focused on determining the prevalence of adequate consumption of iron-rich foods among children aged 6–23 months in SSA, with limited studies specifically investigating iron food deficiency in SSA children. An approach focusing strictly on iron-rich food deficiency allows for a deeper analysis of the factors that contribute to iron deficiency, going beyond merely assessing the consumption of adequate iron-rich foods. Thus, previous studies that only focused on the consumption of adequate iron-rich foods might not have captured the full picture of iron deficiency. By examining factors associated with iron deficiencies, researchers, nutritionists, health promoters and policy implementers in SSA can refine existing interventions and develop new approaches that are better suited to address the root causes of the problem.

This current paper aims to address the existing knowledge gap by examining the prevalence of non-consumption of iron-rich foods and conducting a comprehensive analysis of the factors associated with the limited consumption of iron-rich foods among under-5 children in SSA. The study uses the latest data from Demographic and Health Surveys (DHSs) conducted between 2010 and 2019 in 26 SSA countries. The documentation of factors linked to the inadequate uptake of iron-rich foods holds significant importance for various stakeholders, including nutritionists, public health workers, health promoters and policy-makers. The findings from this present study can provide valuable insights for the formulation of tailored interventions and policies aligned with the United Nations' Sustainable Development Goals (SDGs), specifically SDG 2 (Zero Hunger) and SDG 3 (Good Health and Well-being).[21–23] Thus, this paper contributes to the broader global efforts to combat iron deficiency and improve overall nutritional and health outcomes in under-5 children.[21–23]

METHODS

Overview

DHSs are nationally representative household surveys that collect data on various indicators related to population, health and nutrition. The DHS project, funded primarily by the US Agency for International Development and administered by Macro International, aims to support government and private agencies in developing countries in conducting national sample surveys on population, maternal and child health. The main objectives of the DHS programme include the following: (1) promoting the dissemination and utilisation of DHS data among policymakers, (2) expanding the international population and health database, (3) advancing survey methodology and (4) developing the skills and resources necessary for conducting high-quality DHSs in participating countries.[24]

Data source

For this study, we used the most recent pooled data from the DHSs dataset of 26 SSA countries conducted between 2010 and 2019.[25] The study specifically focused on representative national child data of children under the age of 5 (0–59 months), selected using a two-stage sampling design. The DHS datasets are known for providing reliable information on child health, maternal health, fertility, family planning and nutrition. The countries included in the study were Burkina Faso (2010), Benin (2017), Congo Democratic Republic (2013–2014), Congo (2011–2012), Cote D'Ivoire (2011–2012), Cameroon (2018), Ethiopia (2016), Ghana (2014), Guinea (2018), Kenya (2019), Liberia (2019), Lesotho (2014), Madagascar (2021), Malawi (2015–2016), Mali (2018), Mozambique (2015), Namibia (2013), Nigeria (2018), Sierra Leone (2019), Senegal (2010–2011), Chad (2014–2015), Togo (2013), Tanzania (2015–2016), Uganda (2016), Zambia (2018) and Zimbabwe (2015). The total sample size for under-5 children used in the analysis was 296 850.

Patient and public involvement

No patient was involved in this study.

Study variables

The dependent variable in this study was 'no consumption of iron-rich foods or iron-rich food deficiency'. In the DHS, iron-rich foods were assessed by asking mothers of under-5 children whether their child had consumed specific items (eggs, fish, organ meat, leafy vegetables, beef meat) in the 2 weeks preceding the survey. Based on this DHS methodology, we defined 'iron-rich deficiency' as a state wherein an individual, typically assessed through dietary patterns, lacks adequate consumption of foods recognised for their high iron content, resulting in insufficient iron intake within a given period. This deficiency was determined by evaluating an individual's diet and identifying whether they regularly consume items known to be rich in iron, such as red meat, fish, poultry, leafy green vegetables, beans or fortified cereals.[8 9] In other words, a novel approach was employed to ascertain if a child had not consumed any of the specified iron-rich foods. This involved the creation of a composite variable that was scored as follows: a score of 0 indicated that the child had consumed at least one iron-rich food, while a score of 1 indicated that the child had not consumed any of the specified iron-rich foods. This innovative method aligns with the established DHS methodology for assessing iron-rich food intake.

Based on empirical gaps in previous studies,[12 19 20] we considered 12 explanatory variables, which included child variables, maternal variables and paternal variables. Child variables included sex (1=male, 2=female), age (1=6–18 months, 2=19–37 months, 3=38–59 months) and anaemia level (1=anaemic, 2=not anaemic). Maternal variables encompassed educational level (1=primary, 2=secondary, 3=higher), marital status (1=not married, 2=married), wealth index (1=poor, 2=middle, 3=rich), residence (1=urban, 2=rural), media exposure (1=no, 2=yes), postnatal visit (1=no, 2=yes) and antenatal visit (1=no, 2=yes). Paternal variables included educational level (1=primary, 2=secondary, 3=higher) and work status (1=no, 2=yes).

The selected child variables—sex, age and anaemia level—were crucial to understanding disparities in iron-rich food intake among children, as these factors have shown substantial associations with dietary patterns and health outcomes in prior research.[26 27] Maternal variables, including educational level, marital status, wealth index, residence, media exposure, postnatal visit and antenatal visit, were considered due to their recognised influence on household dietary practices, access to healthcare and socioeconomic status, all of which can significantly impact children's nutritional intake.[28 29] Additionally, the inclusion of paternal variables—educational level and work status—was deemed relevant, acknowledging the role of paternal involvement and socioeconomic contributions in influencing household dietary habits and children's overall well-being.[30 31] This comprehensive set of variables aimed to provide a holistic understanding of the multiple factors shaping iron-rich food intake among children, thereby contributing to a more nuanced analysis.

Data analysis

Stata/SE V.14 software was used to analyse the data. The study employed the 'svyset' command, incorporating the sample weight, strata and primary sampling unit variables to address both primary and secondary stages within the DHSs. This approach facilitated the calculation of weighted percentages and frequencies for categorical variables, ensuring robust analysis. Additionally, to estimate variance accurately, the study applied robust SEs, emphasising a comprehensive approach aimed at enhancing the transparency, rigour and clarity of the analysis in accommodating the complexities inherent in the two-stage sampling design employed within the study.

Prior to analysis, the data underwent cleaning, editing and recoding. Bivariate and multivariate logistic regression analyses were conducted to determine the association between the absence of iron-rich food consumption and sociodemographic characteristics. A correlation matrix was used to assess multicollinearity. Variables that were more correlated with the outcome variables were taken out of the final model. Variables with a p<0.05 were considered statistically significant.

RESULTS

Sociodemographic characteristics of participants

Out of the total sample of 296 850 under-5 children included in the study, slightly over half (50.6%) were males. Approximately 36.2% of the children fell within the age group of 6–18 months. The majority of under-5 children (64.4%) were classified as anaemic, indicating a high prevalence of anaemia among this population. Moreover, more than half (56.5%) of the children were found to not be consuming iron-rich foods. In terms of maternal demographic characteristics, the majority of mothers (65.9%) had attained at least primary education. Married mothers accounted for a substantial proportion (87.5%), while the remaining 12.5% were not married. A significant proportion of mothers (89.5%) attended antenatal care (ANC), reflecting a relatively high utilisation of antenatal services. Regarding paternal characteristics, a notable proportion of fathers (35.9%) had higher education levels. The majority of fathers (66.2%) were actively employed, indicating their involvement in the workforce. These sociodemographic characteristics provide a snapshot of the population under study and highlight important factors that may influence the consumption of iron-rich foods among under-5 children (table 1).

Table 1 Sociodemographic characteristics of the sample

Variables	Frequency=296 850 N (%)	Weighted % (CI)
Child characteristics		
Sex		
Male	150 109 (50.57)	50.63 (50.40 to 50.86)
Female	146 741 (49.43)	49.37 (49.14 to 49.59)
Age group (months)		
6–18	104 758 (36.34)	36.23 (36.01 to 36.44)
19–37	98 993 (34.34)	33.99 (33.77 to 34.20)
38–59	84 540 (29.32)	29.78 (29.52 to 30.03)
Anaemia level		
Anaemic	63 597 (64.68)	64.43 (63.77 to 73.10)
Not anaemic	34 733 (35.32)	35.57 (35.02 to 36.11)
Iron-rich food		
Consumption	77 008 (43.54)	43.44 (42.90 to 43.99)
No consumption	99 869 (56.46)	56.56 (56.01 to 57.10)
Mother's characteristics		
Mother's educational level		
No education	116 107 (39.11)	34.38 (33.82 to 34.95)
Primary	101 269 (34.12)	38.47 (37.72 to 39.22)
Higher	79 467 (26.77)	27.15 (26.58-.27.72)
Marital status		
Not married	37 990 (12.80)	12.51 (12.25 to 12.78)
Married	258 858 (87.20)	87.49 (87.22 to 87.75)
Wealth		
Poor	100 609 (33.89)	36.04 (35.33 to 36.75)
Middle	138 281 (46.58)	43.72 (43.00 to 44.43)
Rich/wealthy	57 960 (19.53)	20.24 (19.88 to 20.61)
Residence		
Urban	85 396 (28.77)	30.08 (29.14 to 31.03)
Rural	211 454 (71.23)	69.92 (68.97 to 70.86)
Media		
No	139 841 (48.10)	47.00 (46.49.66 to 47.52)
Yes	150 914 (51.90)	52.99 (52.48 to 53.51)
Postnatal		
No	110 479 (58.80)	58.96 (58.28 to 59.63)
Yes	77 400 (41.20)	41.04 (40.37 to 41.71)
Antenatal		
No	22 514 (11.20)	10.55 (10.13 to 10.97)
Yes	178 470 (88.80)	89.45 (89.02 to 89.86)
Father's characteristics		
Father's educational level		
No education	87 680 (35.83)	35.59 (34.77 to 36.42)
Primary	68 639 (28.05)	28.51 (27.94 to 29.09)
Higher	88 366 (36.11)	35.90 (35.00 to 36.81)
Work status		

Continued

Table 1 Continued

Variables	Frequency=296 850 N (%)	Weighted % (CI)
No	95 576 (34.16)	33.84 (33.27 to 34.41)
Yes	184 252 (65.84)	66.16 (65.58 to 66.73)

N represents total frequency.

No iron-rich food consumption by sociodemographic characteristics

The study revealed that a higher proportion of male (51%) children did not consume iron-rich foods. Among children in different age groups, the majority of those aged 6–18 months (58%), 19–37 months (21%) and 38–59 months (21%) did not have iron-rich food in their diets. Furthermore, a significant number of children who were identified as anaemic (70%) also did not consume iron-rich foods.

In terms of maternal characteristics, it was found that the majority of mothers with no education (45%) did not provide their children with iron-rich foods. Among married mothers, the majority (91%) did not incorporate iron-rich food into their children's diets. Additionally, mothers belonging to the middle-class (47%) wealth categories did not feed their children with iron-rich foods. Furthermore, a majority of mothers (88%) who attend ANC did not include iron-rich foods in their children's meals. Regarding paternal characteristics, it was observed that a majority of fathers (41%) with no formal education did not provide their children with foods rich in iron.

These findings highlight the concerning patterns of low iron-rich food consumption among children and indicate the influence of maternal and paternal characteristics on this issue. Addressing these factors and promoting awareness about the importance of incorporating iron-rich foods into children's diets is crucial for combating iron deficiency and its associated health implications (table 2).

Prevalence of non-consumption of iron-rich food among under-5 children in SSA

Figure 1 indicates an overview of the prevalence of non-consumption of iron-rich foods among under-5 children in various SSA countries. The results of this study indicate that a significant proportion of children in several countries did not have a dietary intake of iron-rich foods. For instance, in Guinea and Burkina Faso, a staggering 77% of under-5 children did not consume iron-rich food. Similarly, in Benin, the prevalence of non-consumption was 60%, while in Cote d'Ivoire and Ethiopia, it was 59% and 77%, respectively. Other countries with notable prevalence rates of non-consumption of iron-rich foods included Kenya (54%), Guinea (78%), Liberia (58%), Sierra Leone (59%), Senegal (65%), Chad (70%) and Uganda (56%). These findings highlight a concerning trend of inadequate intake of iron-rich foods among children in these countries, suggesting a significant public health concern. Efforts to improve awareness, education and accessibility to iron-rich food sources are crucial in addressing this issue and reducing the prevalence of non-consumption among children in SSA.

Determinants of non-consumption of iron-rich foods

Table 3 presents the determinants associated with the non-consumption of iron-rich foods among under-5 children in SSA. Several factors demonstrated a significant association with the lack of dietary intake of iron-rich foods. Children who were not anaemic had a lower likelihood of non-consumption of iron-rich foods (OR 0.86, 95% CI 0.80 to 0.92), indicating a potential protective effect of anaemia status on dietary intake. Maternal education played a crucial role, with both primary education (OR 0.62, 95% CI 0.57 to 0.68) and higher education (OR 0.58, 95% CI 0.52 to 0.64) showing a reduced likelihood of non-consumption. Residence in a rural area was associated with a higher likelihood of non-consumption (OR 1.12, 95% CI 1.10 to 1.28), suggesting that access to iron-rich foods may be limited in rural settings. Media usage (OR 0.96, 95% CI 0.93 to 0.99), postnatal visits (OR 0.90, 95% CI 0.83 to 0.95) and antenatal visits (OR 0.84, 95% CI 0.74 to 0.95) were all associated with a decreased likelihood of non-consumption, highlighting the importance of healthcare utilisation and access to information. Paternal education also played a role, with both primary education (OR 0.69, 95% CI 0.63 to 0.75) and higher education (OR 0.66, 95% CI 0.60 to 0.73) showing a reduced likelihood of non-consumption. Additionally, paternal working status was associated with a lower likelihood of non-consumption (OR 0.78, 95% CI 0.73 to 0.84). These findings underscore the multifaceted nature of factors influencing the dietary intake of iron-rich foods among children in SSA. Improving maternal education, enhancing healthcare utilisation, addressing rural–urban disparities and promoting paternal involvement may contribute to mitigating the barriers and improving the consumption of iron-rich foods among this vulnerable population.

As depicted in table 3, some variables were excluded from the final model due to issues of multicollinearity. These variables encompassed a range of factors such as anaemia level, mother's education level, marital status, wealth status, residential location, media exposure, postnatal (PNC) and ANC visits, father's education, and work status. Their exclusion from the final model was necessary to ensure the statistical integrity of the analysis, as these variables exhibited high intercorrelation, potentially influencing the model's accuracy and interpretability.

Table 2 Proportion of 'no iron-rich food consumption' by sociodemographic characteristics

Variables	No consumption of Iron-rich food Weighted frequency (%)	Weighted % (CI)
Child characteristics		
Sex		
Male	49 749 (50.53)	50.17 to 50.96
Female	48 710 (49.47)	49.03 to 49.82
Age group		
6–18	56 274 (58.25)	57.75 to 58.37
19–37	20 236 (20.95)	20.60 to 21.17
38–59	20 098 (20.80)	20.75 to 21.37
Anaemia level		
Anaemic	23 016 (70.27)	69.46 to 71.08
Not anaemic	7810 (29.73)	28.91 to 30.54
Mother's characteristics		
Mother's educational level		
No education	44 179 (44.87)	44.86 to 46.73
Primary	31 077 (31.57)	30.84 to 32.28
Higher	23 194 (23.56)	21.99 to 23.31
Marital status		
Not married	9282 (9.43)	8.83 to 9.53
Married	89 174 (90.57)	90.47 to 91.16
Wealth		
Poor	45 902 (32.81)	31.90 to 33.62
Middle	20 248 (46.62)	45.72 to 47.53
Rich/wealthy	32 309 (20.56)	20.07 to 21.18
Residence		
Urban	26 537 (26.95)	25.08 to 27.18
Rural	71 922 (73.05)	72.81 to 74.92.
Media		
No	46 575 (48.29)	47.52 to 49.00
Yes	49 879 (51.71)	50.99 to 52.47
Postnatal		
No	33 994 (62.23)	61.79 to 63.34
Yes	20 635 (37.77)	36.52 to 38.21
Antenatal		
No	7028 (12.43)	11.95 to 13.18
Yes	49 509 (87.57)	86.81 to 88.04
Father's characteristics		
Father's educational level		
No education	34 948 (40.70)	40.58 to 42.64
Primary	22 811 (26.57)	26.08 to 27.53
Higher	28 099 (32.73)	30.73 to 32.46
Work status		
No	37 399 (39.04)	38.33 to 39.87
Yes	58 396 (60.96)	60.13 to 61.67

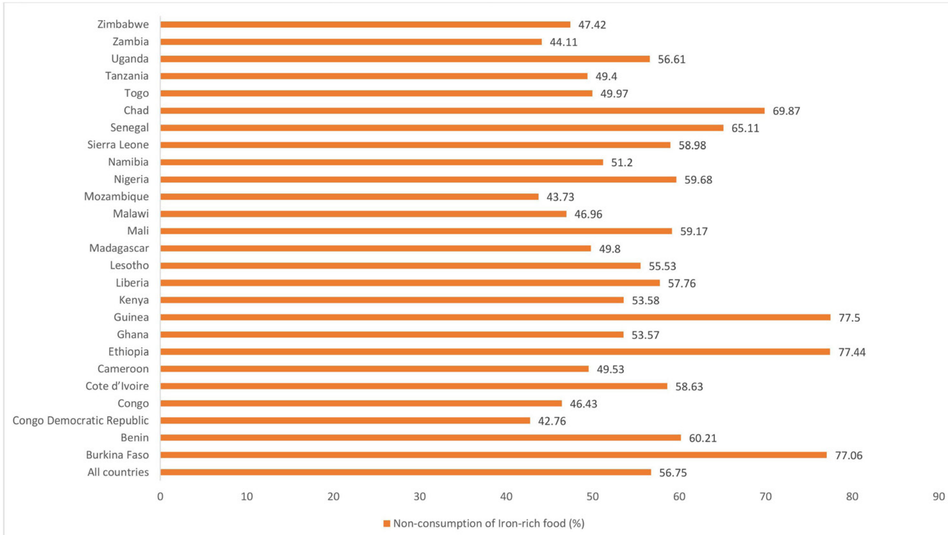

Figure 1 Prevalence of no iron-rich food among under-5 children by countries in SSA. SSA, sub-Saharan Africa.

DISCUSSION

Iron deficiency has detrimental effects on an individual's physical and cognitive development, with under-5 children being particularly vulnerable. In SSA, evidence shows that children face a significant burden of iron deficiency which poses a substantial threat to their development and well-being.[11] However, despite the recognition of iron deficiency in children as a critical public health issue in SSA, little has been done to understand the factors associated with deficiencies in iron-rich food consumption in SSA. Hence, this study has conducted a comprehensive analysis of the factors associated with the limited consumption of iron-rich foods among under-5 children in SSA.

Out of the 296 850 under-5 children observed in this study, a little over 56% did not consume the required iron-rich foods, while 43.7% consumed iron-rich foods as part of their diets. The percentage of children consuming iron-rich foods in SSA is significantly lower compared with other jurisdictions, such as Ireland at 90%,[32] Australia at 82.6%,[33] Mexico at 63.1%[27] and China at 51%.[34] The low iron-rich food uptake among under-5 children in this present study, especially in Guinea demonstrates a pressing need for targeted and evidence-based policy interventions to address the iron-food deficiency in SSA. Policy-makers in SSA countries should prioritise the development and implementation of comprehensive nutrition policies and programmes that focus on promoting iron-rich food consumption among young children. Such policies may include nutritional education and awareness campaigns targeted at parents, caregivers and healthcare providers to raise awareness about the importance of iron-rich diets for children's overall health and development.

Among the 26 SSA countries studied, the top 4 countries with the highest prevalence of non-consumption of iron-rich food were Guinea (77.50%), Ethiopia (77.44%), Burkina Faso (77.06%) and Chad (69.87%), while the countries with the lowest prevalence were Congo Democratic Republic (42.76%), Mozambique (43.73%), Zambia (44.11%) and Congo (46.43%). The variations in the prevalence of non-consumption of iron-rich food among the 26 SSA countries studied show the need for targeted and context-specific policy interventions to address iron-food deficiency in the region. Policy-makers should focus on designing tailored strategies to target the countries with the highest prevalence of non-consumption, namely Guinea, Ethiopia, Burkina Faso and Chad. Thus, in these high-prevalence countries, comprehensive nutrition policies should be formulated and implemented to raise awareness about the importance of iron-rich diets for children's health and development. Several factors including, economic reasons, sociocultural determinants, dietary preference, lack of nutrition knowledge and natural factors may have accounted for this variation in the prevalence. Studies have revealed the high cost of animal-source foods and low household income as key to low consumption of iron-rich foods.[20 35] For instance, in terms of sociocultural practices, a study by Tiruneh *et al*, revealed that in some parts of Ethiopia, animal-source foods are usually considered luxury food rather than an essential part of daily children's diet, and thus, consumed during special occasions. Such factors indicate that besides the economic factors, the social norms and beliefs across the SSA regions may contribute to the variations in prevalence.[20]

Findings from this study further indicate the association of maternal and paternal characteristics with the low uptake of iron-rich foods among under-5 children in SSA. It was found that mothers and fathers with no education were likely to not provide their children with iron-rich foods. This is consistent with results obtained in Nepal,[36] Mexico[37] and Ethiopia.[20] According to Prickett and Augustine, children born to mothers with formal education are more likely to have healthy child-feeding practices.[38] There are several plausible reasons why parents with no formal education might be less likely to provide

Table 3 Associations between no intake of iron-rich foods and participant characteristics

Variables	Model I (unadjusted) OR (95% CI)	P value	Model II (adjusted) OR (95% CI)	P value
Child characteristics				
Anaemia level				
Anaemic	**Ref.**		**Ref.**	
Not Anaemic	0.96 (0.91 to 1.00)	0.071	0.86 (0.80 to 0.92)	**<0.001**
Mother's characteristics				
Mother's educational level				
No education	**Ref.**		**Ref.**	
Primary	0.61 (0.59 to 0.64)	**<0.001**	0.62 (0.57 to 0.68)	**<0.001**
Higher	0.55 (0.53 to 0.58)	**<0.001**	0.58 (0.52 to 0.64)	**<0.001**
Marital status				
Not married	**Ref.**		**Ref.**	
Married	1.27 (1.20 to 1.34)	**<0.001**	1.17 (0.87 to 1.56)	0.290
Wealth				
Poor	**Ref.**		**Ref.**	
Middle	1.18 (1.12 to 1.23)	**<0.001**	0.99 (0.91 to 1.08)	0.869
Rich/wealthy	1.15 (1.10 to 1.21)	**<0.001**	1.05 (0.96 to 1.15)	0.282
Residence				
Urban	**Ref.**		**Ref.**	
Rural	1.24 (1.19 to 1.31)	**<0.001**	1.12 (1.10 to 1.28)	**0.004**
Media				
No	**Ref.**		**Ref.**	
Yes	0.96 (0.93 to 0.99)	**0.016**	0.96 (0.93 to 0.99)	**0.003**
Postnatal				
No	**Ref.**		**Ref.**	
Yes	0.80 (0.77 to 0.83)	**<0.001**	0.90 (0.83 to 0.95)	**0.001**
Antenatal				
No	**Ref.**		**Ref.**	
Yes	0.64 (0.60 to 0.68)	**<0.001**	0.84 (0.74 to 0.95)	**0.004**
Father's characteristics				
Father's educational level				
No education	**Ref.**		**Ref.**	
Primary	0.59 (0.56 to 0.62)	**<0.001**	0.69 (0.63 to 0.75)	**<0.001**
Higher	0.56 (0.53 to 0.59)	**<0.001**	0.66 (0.60 to 0.73)	**<0.001**
Work status				
No	**Ref.**		**Ref.**	
Yes	0.75 (0.72 to 0.78)	**<0.001**	0.78 (0.73 to 0.84)	**<0.001**

Model 1: unadjusted covariates.
Model 2: adjusted for anaemia level, mother's education level, marital status, wealth, residence, media, postnatal visit, antenatal visit, father's education and work status.
Significant values (p-values<0.05) are in bold.

their children with iron-rich foods. First, the absence of formal education might limit these parents' access to critical information sources such as healthcare providers, educational materials or reliable channels that emphasise the importance of iron-rich foods in a child's diet.[39] Moreover, families without educational backgrounds often face financial constraints, potentially hindering their ability to purchase or afford foods that are rich in iron.[40] Additionally, parents lacking education might experience feelings of disempowerment or a lack of confidence in making informed decisions about their children's nutrition.[41] They may rely on alternative sources of information that might not prioritise nutritional needs. Therefore, it is reasonable to suggest that unlike those with no formal education in SSA, mothers with some level of formal education were more exposed to information on the benefits of childhood nutrition, which may have influenced their better feeding experience.[39] In light of this finding, it is important to promote childhood nutritional counselling, especially for mothers with lower levels of education in order to foster better nutritional status of under-5 children in SSA. Policy-makers should invest in educational campaigns that specifically address the significance of iron-rich foods for children's development and health outcomes. These campaigns can provide practical information on the types of iron-rich foods available, their benefits and how to incorporate them into daily diets. Additionally, efforts should be made to enhance access to formal and informal educational opportunities for parents with lower levels of education. By increasing access to education, particularly in disadvantaged communities, parents can be better equipped to make informed decisions about their children's nutrition and well-being.

Moreover, the wealth status was associated with good consumption of iron-rich foods. The findings show that children from rich/wealthy households are more likely to consume iron-rich foods as compared with middle-wealth households and poor households. This is consistent with a study in Mexico[42] and other low-income countries.[43] Wealth status may be linked to better consumption of iron-rich foods due to several interconnected factors. First, wealthier individuals typically have greater financial resources, enabling them to afford a wider variety of nutritious foods, including those rich in iron.[12 44] They can purchase diverse foods that are naturally high in iron or fortified with iron supplements, thus improving their overall dietary intake.[44] Additionally, higher wealth status often correlates with improved access to markets, supermarkets or specialty stores offering a broader selection of fresh fruits, vegetables, meats and fortified food products.[45] This accessibility facilitates easier acquisition of iron-rich foods, contributing to a more balanced diet.[45] Furthermore, wealthier individuals tend to prioritise health and well-being, which often translates to a more health-conscious lifestyle.[46] They may be more inclined to follow recommended dietary guidelines and invest in foods known for their nutritional value, including those rich in iron, to maintain optimal health for themselves and their families.[46] It could, therefore, be assumed that the high household wealth status provides the household with the needed financial resources to access and afford iron-rich foods for their children. Low-income households need to look out for affordable iron-rich foods such as vegetables, beans and fruits.

We further found that mothers who attended ANC and/or PNC were more likely to include iron-rich foods in their children's meals than those mothers who did not attend ANC and PNC. Our findings corroborate a study in Nepal,[36] which indicated that the prevalence of good consumption of iron-rich foods is higher in children of mothers who attended ANC and PNC visits than in children whose mothers did not attend ANC and PNC visits. Plausible reasons for this finding may include the point that ANC and PNC sessions offer valuable opportunities for health education.[47] During these sessions, mothers commonly receive information and guidance on proper nutrition for themselves and their infants, hence, encouraging them to prioritise iron-rich foods in their children's meals.[48] Also, healthcare providers during ANC and PNC visits offer tailored advice and recommendations specific to the mother and infant's health needs.[48] They may emphasise the inclusion of iron-rich foods, providing practical suggestions and tips on how to incorporate these foods into the child's diet effectively.[48] Moreover, through regular check-ups and follow-up visits, healthcare providers monitor the child's growth and development.[48] This ongoing engagement reinforces the importance of nutrition, prompting mothers to remain vigilant about including iron-rich foods to support their child's overall health and well-being. Therefore, considering the importance of ANC and PNC visits in child nutrition, it is important to provide and encourage community-based ANC and PNC in SSA.

Furthermore, the findings indicate that residence in a rural area is associated with a higher likelihood of non-consumption of iron-rich foods (OR 1.12, 95% CI 1.10 to 1.28). This suggests a lack of accessibility and affordability of iron-rich foods in rural settings. This may be due to several reasons, including poor financial resources of rural households, lack of health facilities for ANC and PNC visits, low level of education in rural areas and lack of information, all of which have been found to influence the access to iron-rich foods.[12 19] Concerning access to information, it was found that mothers who were exposed to media were more likely to feed their children with iron-rich foods than mothers without media exposure (OR 0.96, 95% CI 0.93 to 0.99). This is consistent with findings from a study by Dhawan *et al* which examined the effectiveness of mass media and nutrition education interventions for infants and young children feeding.[49] Typically, mass media provides a significant source of information, which is important for providing education and training to mothers about nutrition and appropriate feeding practices for their children.[50]

Finally, we found that children who were not anaemic had a lower likelihood of non-consumption of iron-rich foods (OR 0.86, 95% CI 0.80 to 0.92), indicating a potential protective effect of iron-rich foods from anaemia. Studies have emphasised that poor intake of iron-rich foods in diet and unavailability of iron-rich foods are some of the major causes of anaemia, commonly referred to as iron deficiency anaemia.[51] For instance, it is a common practice to estimate the prevalence of iron deficiency by relying on the prevalence of anaemia in the blood.[4–6] Given that non-consumption of iron-rich foods is associated with compromised physical and cognitive development, the prevention of iron deficiency is crucial.

Strengths and limitations

This study demonstrates several notable strengths that significantly enhance its credibility and contribution to the existing body of knowledge. First, the study employed nationally representative data encompassing 26 SSA countries. This extensive coverage underscores the validity and reliability of the analysis by providing a broader representation of the region's diverse populations, cultures and socioeconomic contexts. Moreover, a distinctive strength lies in the study's innovative focus on 'deficiencies' in iron-rich food intake, diverging from previous research that predominantly centred on the consumption of iron-rich foods. This unique approach adds depth and breadth to the existing literature by shifting the examination towards assessing 'deficiencies' in iron-rich food intake.

While acknowledging the study's strengths, it is important to interpret the findings within the context of certain limitations. First, the dataset used in the analysis for different countries was collected at different points in time, potentially under-representing the current prevalence of non-consumption of iron-rich foods. It is not unlikely that the prevalence of non-consumption of iron-rich foods may have been improved over the years as some data were collected over a decade ago. In addition, DHS data are largely self-reported thereby potentially causing information recall challenges and making social desirability responses likely, potentially affecting the accuracy of reported dietary habits. Due to the cross-sectional design employed in this study, establishing causality among the variables under investigation was not feasible, limiting the study to establishing associations. Cross-sectional studies capture data at a single point in time, providing a snapshot of the relationship between variables but lacking the capability to ascertain the direction or causative influence among them over time. As such, correlations and associations were rather established, and inferring causal relationships between the variables remains outside the scope of this study's methodology. Additionally, the absence of cultural variables in the DHS data represents a significant limitation in understanding the full picture of factors influencing iron-rich food intake among under-5 children in SSA. Culture plays a fundamental role in shaping dietary practices and food choices, and its influence on nutrition is critical to consider when developing effective interventions. Also, some variables, particularly age and sex were dropped from the final model due to multicollinearity which could have affected the model's completeness and interpretability.

To address these limitations in future research, longitudinal studies encompassing multiple time points could track changes in dietary patterns over time, ensuring more accurate and current representations of iron-rich food consumption trends. Using mixed-methods approaches, such as combining self-reporting with objective measures, might mitigate the biases associated with self-reported data. Further research should consider incorporating cultural variables to better understand and tailor interventions to specific cultural contexts. Despite these limitations, the findings of this study provide scientific evidence that could be further explored and/or used to design population-specific interventions to improve the nutritional health and well-being of under-5 children in SSA.

Implications for policy

The findings of this study have implications for public health policy and practice. The relatively high proportion of under-5 children not consuming iron-rich foods, despite the health benefits of these foods, indicates the policy gaps in existing maternal and child health in some of the SSA countries. The results of this study have implications for the reformulation and re-evaluation of poverty alleviation and/or eradication policies and strategies as the findings suggest that poverty is a significant determinant of non-consumption of iron-rich foods. Also, there is a significant between-country disparity in the prevalence of non-consumption of iron-rich foods in the subregion. This indicates a need to strengthen health advocacy and equitable policies to reduce within- and between-country disparities in nutritional health among under-5 children. The results of this study also have implications for enhancing nutritional education for children and both parents to achieve the child's nutritional objectives. Specifically, the findings underscore the pressing need for targeted policy actions to uplift the nutritional status of under-5 children in SSA. First, enhancing maternal and child health policies could involve incorporating specific nutrition-focused interventions, such as the inclusion of iron-rich food provisions in government-supported maternal and child health programmes. This might entail the establishment of nutrition supplementation programmes or the integration of nutrition counselling during ANC and PNC visits. Second, addressing poverty-related undernutrition could involve policy initiatives like subsidising or providing vouchers for nutrient-dense foods targeting economically disadvantaged families. For instance, implementing a voucher programme that enables families with limited financial means to access nutritious foods like fortified cereals, legumes and vegetables. Additionally, promoting equitable access to nutritional resources across SSA countries might involve creating cross-border collaborations to share successful nutritional intervention strategies and establish regional policies ensuring standardised access to fortified foods and nutritional supplements. Furthermore, incorporating comprehensive nutrition education into school curricula and early childhood development programmes could involve policies mandating nutrition education in primary school syllabi or integrating nutrition workshops for caregivers in early childhood centres, emphasising the importance of balanced diets and iron-rich foods for child health. Deploying these specific policy interventions tailored to SSA's context holds immense potential to significantly enhance the nutritional outcomes for under-5 children in the region. To this end, it is important to develop viable policies which target the school and early childhood education as contexts to realise child nutritional and overall health goals. Further studies should enhance our understanding of the sociocultural determinants influencing the deficiencies in the consumption of iron-rich foods by employing qualitative and longitudinal research methods. Additionally, conducting a more comprehensive and detailed comparative analysis to examine the factors that influence the intake of iron-rich foods between children over the age of 5 and those under would significantly augment our insights into this area of study.

Conclusions

This study results showed a relatively high prevalence of non-consumption of iron-rich foods among under-5 children in SSA as only two in five children reported adequate consumption of iron-rich foods. Maternal and paternal education, household wealth indices and place of residence were found as significant determinants of non-consumption of iron-rich foods. Based on these findings, it is imperative for effective interventions aimed at reducing household poverty and empowering parents and caregivers with requisite nutritional knowledge and skills to be developed to address the challenge of non-consumption of iron-rich foods among under-5 children in SSA. This way, immediate and future health implications of iron deficiency would be prevented among this population.

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Ethics approval This study used publicly accessible survey data from the MEASURE DHS programme, for which ethical approval and participant consent were not required. Permission was obtained from http://www.dhsprogram.com to download and use the data for this study. The datasets used in the analysis do not contain any personally identifiable information or household addresses.

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