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# Dietary quality, anaemia prevalence and their associated factors among rural school- going adolescents in Acholi sub -region of Uganda

Gloria Adokorach[1], Sunday Mark Oyet[1], Gerald Obai[2] and Christopher Muggaga[3*]

## Abstract

**Background** Globally, iron deficiency anaemia is a widespread public health problem affecting vulnerable populations including adolescents. However, over the years, the Uganda Demographic Health Surveys mostly report the status of anaemia for women of reproductive age (15–49 years) and children up to 5 years, leaving out the focus on adolescents. Moreover, high prevalence of anaemia among children below five years could suggest that anaemia still persists at adolescence. Therefore, the study aimed at determining dietary quality, prevalence of anaemia and their associated factors among school-going adolescents.

**Methods** A cross-sectional study involving 341 adolescent boys and girls aged 10–19 years was carried out in two rural schools in Gulu district. Prevalence of anaemia was determined by obtaining blood specimens from a finger prick into a microcuvette and analysed for haemoglobin (Hb) level using Haemoglobin analyser, whereas dietary quality was assessed using the Individual Dietary Diversity Score (IDDS). Socio-economic and demographic data were collected using a semi-structured questionnaire.

**Results** The overall prevalence of anaemia was 16.0% (Girls:18.1%; Boys:13.0%), while the mean Hb level was 13.2 ± 1.4 g/dl (Girls 13.0 ± 1.3 g/dl; Boys 13.5 ± 1.6 g/dl). The mean number of food groups consumed among the adolescents was 3.5 ± 2.1 for girls and 3.0 ± 1.8 for boys ($p$>0.05). Animal source foods, fruits and vitamin A-rich vegetables, other fruits and vegetables were consumed by adolescent girls more than the boys. Similarly, a higher proportion of adolescent girls than boys consumed iron-rich foods: fish and meat, organ meat and dark green leafy vegetables. Further, all the socio-demographic factors in the study did not predict dietary diversity ($p$ > 0.05). On the other hand, education attainment by parent/guardian and nature of menstruation predicted the prevalence of anaemia amongst adolescents ($p$ < 0.05).

**Conclusions** The prevalence of anaemia was high among adolescents. Coupled with this, there, was low dietary diversity among the adolescents. The level of education of the parent/guardian and nature of the menstrual discharge were significant predictors of anaemia amongst girls. From this study, we recommend interventions by both health and agricultural-related practitioners to strengthen activities in rural schools such as health and nutrition education to create awareness about dietary diversity and promotion of agricultural practices such as school vegetable gardens,

*Correspondence:
Christopher Muggaga
c.muggaga@gu.ac.ug
Full list of author information is available at the end of the article

orchards poultry production and rearing of small ruminants to support consumption of diverse foods in schools with the view of reducing the burden from iron deficiency anaemia.

**Keywords** Anaemia, Adolescents, Dietary iron adequacy, Dietary diversity, Iron intake, Gulu, Uganda

## Introduction

Globally, anaemia is a public health concern with more than 2 billion people being affected [1], most of whom are women of reproductive age (WRA) (15–49 years), children under 5 years, infants and adolescents, elderly persons, and people with chronic inflammatory diseases [2–4]. Of the anaemia cases, iron deficiency anaemia (IDA) accounts for half of the global cases [5, 6]. The prevalence of anaemia in the world is disproportionately presented, where the developing countries are affected more than the developed ones [1, 7, 8]. For instance, Sub-Saharan Africa and South Asia were reported to have the highest prevalence of anaemia. As such, at country level, a prevalence of 20% or more of anaemia among WRA persists as public health problem at a moderate-to-severe levels in most WHO member states [9]. The situation is not any better for Uganda among young children where some studies indicated high prevalence of anaemia among children, varying according to age and location. For instance, in mid-western Uganda, there was a high prevalence (45.9%) of mild to moderate anaemia among school-going girls 11–14 years [10]. Also, in West Nile subregion of Uganda, the overall prevalence of anaemia was 34.4%, varying according to age group: 1–5 years (37.2%), 6–11 years (33.3%) 12–14 years (11.8%) [11, 12]. In East-central region of Uganda, the prevalence of anaemia among children aged 6 to 59 months was as high as 58.8%. Whereas overall in Uganda, the prevalence of anaemia among WRA and children under 5 years of age was 32% and 53%, respectively, Acholi sub-region in northern Uganda experienced the highest prevalence accounting for 47% and 71% among WRA and children below five (5) years, respectively [13]. However, the extent to which anaemia occurs in school-going adolescents is largely unknown in Uganda. As such, it is evident that the Uganda Bureau of Statistics and Inner-City Fund International (UBOS and ICF) [14] report on anaemia considered broad range of age (15–49 years) for women, where specific information on school-going adolescents is lacking, particularly for both girls and boys. In the face of inadequate national data for anaemia among school-going adolescents in Uganda, some previous studies indicated that the occurrence of anaemia was higher in adolescent females than in males [1, 14]. Similarly, prevalence of anaemia among adolescent girls was reported to be 6% in developed nations compared to 27% in developing nations [15, 16] such as Uganda.

Adolescence is characterized by rapid physical growth, cognitive development as well as physiological changes which predisposes them to increased risk of iron deficiency anaemia (IDA) [15]. This suggests that IDA is linked to poor brain development, stunted growth, reduced immunity, menstrual irregularities and increased susceptibility to infections [6–8, 16–19]. More so, dire effects on academic performance [20, 21], and economic development [22] have been attributed to IDA.

The causes of anaemia are multifaceted and include but not limited to; inadequate intake of bio-available iron or mal-absorption of iron from the diet [23, 24], high consumption undiversified diets [25–27], excessive menstrual blood loss, acute and chronic inflammation, infections like malaria, HIV, worm infestation [6, 20, 28–30]. Furthermore, socio-demographic factors such as mother's education [19], menstruation [24, 28], household family size, average household monthly income, history of intestinal parasitic infection, duration of menstruation flow [6] have been cited as predictors of IDA. Among the causes of anaemia, inadequate dietary intake has been regarded as the main cause of IDA [29, 31]. This can result from inadequate intake of bio-available iron or mal-absorption of iron from the diet [23, 24] as well as high consumption of undiversified diets [25–27]. Adolescent school-going children appear to experience more nutrition challenges than non-school-going ones because school meals are meant to address only one-third of their daily energy and nutrient requirements [30]. Further School foods in Uganda are un-uniform and meals served at the schools are inadequate affecting the nutrition and health outcomes of children [32]. Although the main source of iron is diet related [33], there is insufficient data on dietary iron intake among school-going adolescents in Uganda. Furthermore, there is inadequate information on determinants of anaemia particularly in Acholi sub-region where high prevalence was reported. By implication, paucity of information about the status of anaemia, dietary iron intake and associated predictors among adolescents is likely to complicate efforts towards mitigating IDA in Uganda. Therefore, the study aimed at determining the status of dietary quality, dietary iron intake, anaemia and their associated factors among adolescents in secondary schools of Gulu district. The present study provides opportunities for new directions in addressing anaemia among school-going adolescents by providing evidence-based information in Acholi sub-region.

Nonetheless, this study contributes to the existing body of knowledge, which is important in addressing the endemic challenge of IDA amongst school-going adolescent in Uganda and beyond.

## Methods

### Study design and setting

The current study employed a cross-sectional design in which a quantitative approach was used. The study was carried out in Gulu district situated in the Northern part of Uganda. The district is bordered by Lamwo, Pader, Omoro, Amuru and Gulu City (Fig. 1). Administratively, the district has one county (Aswa County) divided in to eleven sub-counties (Fig. 1). Gulu district is inhabited by the Acholi tribal community, who speak Acholi (Luo) dialect. The district is located in Acholi sub-region of Uganda, which was reported to have the highest prevalence of child and maternal anaemia [13]. Therefore, the current study was conducted among school-going adolescent girls and boys in selected public mixed day and boarding schools in Gulu district. In the current study, we considered adolescents as persons aged 10–19 years [16, 34].

### Sample size estimation and sampling technique

The number of adolescents was calculated according to Taherdoost [35].

$$\text{Hence, Sample size (n)} = \frac{Z^2 P(1-P)}{d^2} \quad (1)$$

where,

n = the sample size required.

z = the confidence level at 95% (with standard value of 1.96).

P = the estimated prevalence of anaemia among rural non-pregnant women (15–49 years of age) in Acholi sub-region reported at 47.1% [13]

d = the margin of error put at 5% (with standard value of 0.05)

$$n = \frac{1.96^2 * 0.471(1-0.471)}{0.05^2} = 383$$

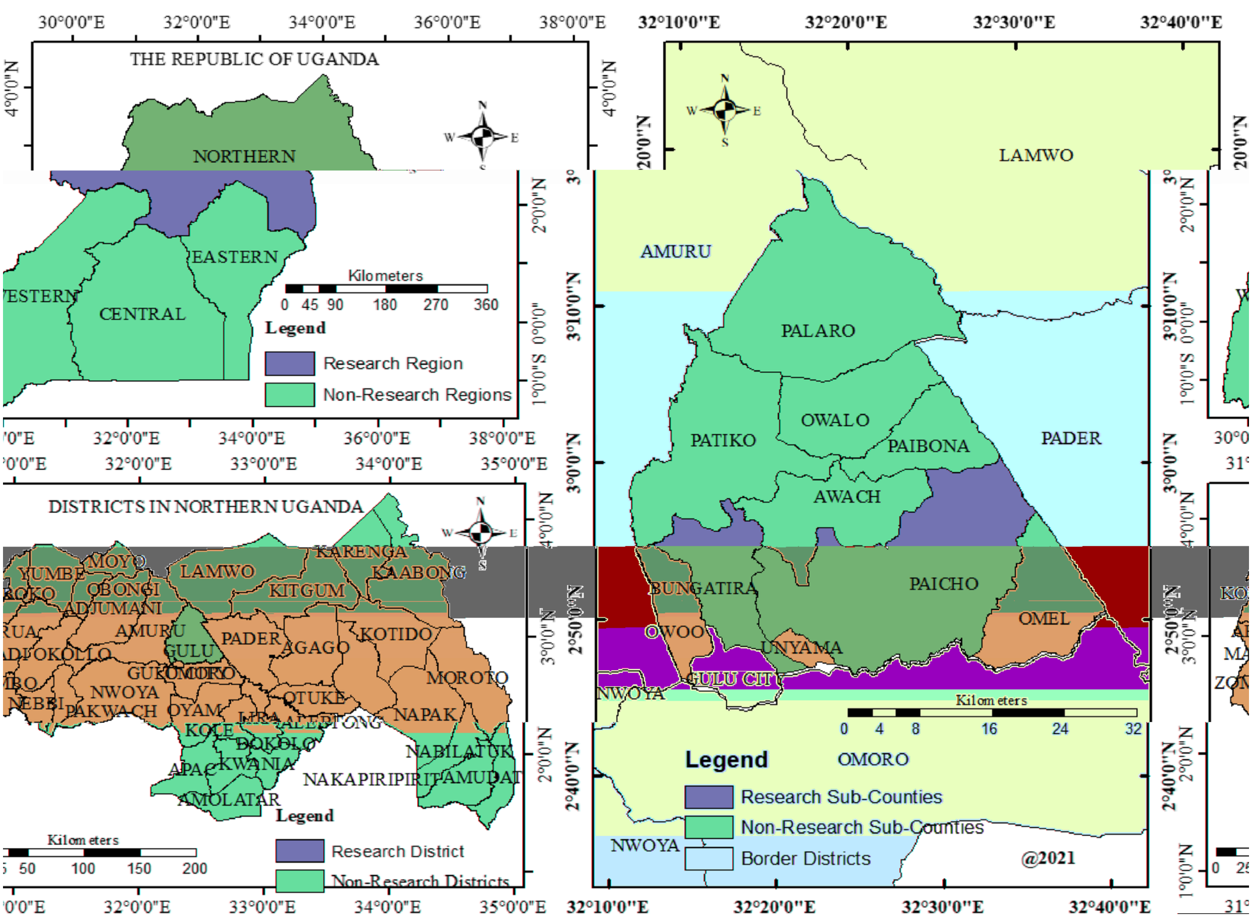


**Fig. 1** A map of Gulu district (2022) showing the research sub-counties

The number of participants was adjusted to 384 to ensure equal representation of boys and girls. In the current study, pregnant adolescent girls, adolescents who had chronic illnesses, or recent infections such as malaria, diarrhoea (all self-reported) were excluded.

A multi-stage sampling technique was used. First, because there was no heterogeneity in the population, simple random sampling undertaken by ballot method was used to select two (2) of the eleven (11) sub-counties. Hence, Bungatira and Paicho sub-counties were selected. The second stage involved selecting one school by ballot from a list of secondary schools in each of the selected sub-counties. Accordingly, Lukome and Paicho senior secondary schools were selected. In the third stage, a sampling frame was created for adolescent boys and girls from the school register, followed by selecting the participants by systematic random sampling. From the 384 participants, only 341 (89.03%) students (194 girls and 147 boys) completed the study while 43 declined to take part in the study due to fear of finger prick during collection of blood samples.

### Data collection

Prevalence of anaemia in the current study was determined by obtaining blood specimens from a finger prick into a microcuvette and analysed for Hb level with a battery operated hand-held Hb analyser (DiaSpect Medical GmbH; Serial No:3200–0011; Germany) [13]. Therefore, blood samples were collected by a qualified medical laboratory technician. Before blood was drawn, the fingertip was sterilised using disinfectant. Thereafter, blood from a finger prick was first drawn into a microcuvette and then inserted in Hb analyser to read the level of Hb (g/dl) on-site.

Dietary quality was assessed using the individual dietary diversity score (IDDS) questionnaire [36]. This questionnaire consists of 12 food groups. However, we adopted 9 food groups being used by previous scholars [37, 38] as proxy for micronutrient adequacy, especially considered to be adequate when an individual ate at least four (4) of the nine (9) specified food groups in the previous 24-h. The 9 food groups were: (i) starchy staples; (ii) legumes nuts and seeds; (iii) meat and fish; (iv) organ meat; (v) eggs; (vi) milk and its products; (vii) dark green leafy vegetables; (viii) vitamin A rich fruits and vegetables; (ix) other fruits and vegetables [36]. Responses for dietary diversity scores are binary: 1 assigned where the food groups were consumed in the previous 24 h and a 0 where the food groups were not consumed. Further, assessment of dietary iron adequacy was focused on the consumption iron-rich foods: meat and fish, organ meat and dark green leafy vegetables.

Socio-demographic data were collected using a structured questionnaire. These included; age of the respondent, caretaker of the respondent, class of the respondent, highest education level of their parent/guardian, size of household, parent/guardian's occupation as well as nature of the menstrual flow and duration of menstruation (days) for female participants.

To ensure data quality, training of the research assistants was carried out prior to data collection so as to create an understanding of the ethics and research protocol. The research assistants also participated in pre-testing of the research tools among 20 partcipants in order to familiarise with the tool and to ensure that the questions were accurate, clear and correctly interpreted. A qualified medical personel was also hired to collect blood samples.

### Data analysis

Data were entered into Microsoft Excel worksheet and cleaned before exporting to Statistical Package for Social Scientists (SPSS) version 20 and STATA software version 13 to generate descriptive statistics. Normality of the data was checked using a normal Q-Q plot and all data for the current study were normally distributed.

The prevalence of anaemia among the adolescent girls and boys was calculated based on Hb cut-offs of $< 12.0$ g/dl and $< 13.0$ g/dl), respectively [39]. Furthermore, an independent sample t-test was undertaken to compare the mean difference in Hb levels between adolescent girls and boys at 5% significance level. Dietary quality was analysed using descriptive statistics and presented as proportion of adolescent boys and girls who consumed a particular food group, and those who consumed at least four of the nine food groups. Dietary quality as measured by the individual dietary diversity score (IDDS) was categorized "low" if less than 4 food groups ($< 4$) were consumed by the individual and "high" if 4 or more food groups ($\geq 4$) were consumed [36]. The association of consumption of food groups by the adolescent girls and boys was analysed using Chi-Square test. Further, an independent sample t-test was used to compare the mean dietary quality between adolescent girls and boys, while the proportion of adolescents who consumed iron-rich foods was compared between boys and girls.

Socio-demographic determinants of anaemia and dietary quality were analysed by linear regression and binary logistic regression, respectively. In the case of linear regression model, the dependent variable was Hb levels whereas for binary logistic regression, the dependent variable was IDDS. In addition, both linear regression and binary logistic regression, dummy variables of the socio-demographic factors were first created before analysis with Hb levels (continuous variable) and a binary response function for dietary diversity.

A total of 8 socio-economic and demographic variables were included in the models, age of respondent ($X_1$), caretaker of the respondent ($X_2$), class of the respondent ($X_3$), highest level of education of the parent/guardian ($X_4$), household size ($X_5$), occupation of the parent/guardian ($X_6$), nature of the menstrual discharge (for females only, self-reported) ($X_7$), and duration of menstruation (days) (for females) ($X_8$).

The relationship was predicted by the following equations:

$$\text{Linear regression model}: \ Y = \beta o + \beta X + E \quad (2)$$

$$\text{Therefore}: \ \text{Yh} \ = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots\ldots\ldots \beta_8 X_8 \quad (3)$$

where $Y_h$ = continuous variable i.e. Hb levels

$$\text{Binary logistic regression model}: \ Y = \beta o + \beta X + E \quad (4)$$

$$\text{Therefore}: \ Y \ = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots\ldots\ldots \beta_8 X_8 \quad (5)$$

where Y = binary status variable i.e. dietary diversity score (1, if an adolescent has high dietary diversity score; 0, if an adolescent has low dietary diversity score).

$\beta_0$ is the vector of unknown parameters (intercept).

E is the error term.

$\beta_1$, $\beta_2$, $\beta_3$, $\beta_4$,............$\beta_8$ are the regression coefficients for the independent variables.

## Results

### Socio-demographic characteristics of the respondents and their parents

More than half of the participants (56.9%) were females. Majority of adolescents (82.7%) were living with their parents at the time of interview. A high proportion of parent/guardians attained primary education (47.8%) followed by secondary (31.7%). In relation to occupation, most of the parents/guardians were primarily peasant farmers (63.3%). The average age and household size of the participants were 15.8 years and 7.2 members, respectively (Table 1). Furthermore, a high the proportion of female participants took four (4) (64.4%) days during menstruation, followed by more than 5 days (12.9%). As far as the nature of menstruation is concerned (Table 2), majority of the female participants (69.1%) described their menstrual discharge as being moderate, whereas 10.8% described their menstrual blood flow as being heavy.

**Table 1** Socio-demographic characteristics of the respondents and their parents

| Variable | Number of participants | Percentage (%) |
|---|---|---|
| **Sex of the respondents** | | |
| Male | 147 | 43.1 |
| Female | 194 | 56.9 |
| **Caretaker** | | |
| Living with the parents | 282 | 82.7 |
| Living with the guardians | 59 | 17.3 |
| **Education level of the Caretakers** | | |
| Primary | 163 | 47.8 |
| Secondary | 108 | 31.7 |
| Tertiary | 70 | 20.5 |
| **Main Occupation of the Caretakers** | | |
| Peasant farmer | 216 | 63.3 |
| Civil servant | 79 | 23.2 |
| Self employed | 46 | 13.5 |
| **Age of the respondents** | | |
| 12–15 years | 134 | 39.3 |
| 16–19 years | 207 | 60.7 |
| **Household size of respondents** | | |
| 1–5 persons | 84 | 24.6 |
| 6–10 persons | 227 | 66.6 |
| 11–15 persons | 27 | 7.9 |
| 16–20 persons | 3 | 0.9 |

**Table 2** Menstrual characteristics of adolescent girls

| Menstrual Characteristics | n | Percentage (%) |
|---|---|---|
| ***Number of menstrual days*** | | |
| 2 days | 40 | 20.6 |
| Four days | 125 | 64.4 |
| More than 4 days | 25 | 12.9 |
| Have no experiencing yet | 4 | 2.1 |
| ***Nature of menstrual discharge/flow*** | | |
| Light | 33 | 17.0 |
| Moderate | 134 | 69.1 |
| Heavy | 21 | 10.8 |
| Have not experienced yet | 6 | 3.1 |

*n* number of adolescent girls = 194

Nature of menstrual flow was based on the amount of discharge as experiences and self-reported by the participants

### Prevalence of anaemia

The results for Hb levels and prevalence of anaemia (Table 3) indicate that generally, the level of Hb in the blood of the participants was 13.2 ± 1.4 g/dl. However, male adolescents had significantly higher Hb level compared to female adolescents ($p = 0.005$; male: 13.5 ± 1.6 g/dl; female: 13.0 ± 1.3 g/dl). On the other hand, the overall prevalence of anaemia was 16.1% and was significantly higher ($p = 0.005$) in girls (18.0%) than in the boys (13.6%).

**Table 3** Mean haemoglobin (Hb) level and prevalence of iron deficiency anaemia among adolescents segregated by sex

| Categories | Hb level (g/dl) | Girls | | Boys | | Total | | |
|---|---|---|---|---|---|---|---|---|
| | | n | % | n | % | n | % | *p*-value |
| Anaemic | < 12 | 35 | 18.0 | 20 | 13.6 | 55 | 16.1 | 0.005 |
| Non-anaemic | ≥ 12 | 159 | 82.0 | 127 | 86.4 | 286 | 83.9 | |
| Mean Hb (g/dl) | | 13.0 ± 1.3 | | 13.5 ± 1.6 | | 13.2 ± 1.4 | | |

*n* number of participants, % percentage of respondent, *P*-value significant at 0.05 level

## The status of dietary quality and dietary iron intake among adolescent girls and boys

The results (Table 4) indicate significant differences ($p < 0.05$) in consumption of starchy staples, milk and its products and vitamin A rich fruits and vegetables between the adolescent girls and boys. Consumption of iron-rich food groups such as meat and fish, organ meat and dark leafy green vegetables accounted for 12.4–29.4% among adolescent girls compared to 8.8–25.9% for the boys. Regarding consumption of food groups of plant origin, majority adolescent girls and boys consumed legumes/seeds/nuts. In contrast, dark green leafy vegetables together with other fruits and vegetables were consumed by few adolescents accounting for between 26.3–29.9% and 23.8–30.2% for girls and boys respectively.

There was generally low dietary diversity among adolescent girls and boys as indicated by the mean number of foods consumed (girls: 3.5 ± 2.1; boys: 30 ± 1.8). Low dietary diversity accounted for 53.6% and 46.4% among adolescent girls and boys, respectively. In relation to the number of food groups consumed, there was no significant difference (p>0.05) in level of dietary diversity between the adolescent girls and boys (Table 5). Iron-rich foods such as flesh meat and organ meat (Fig. 2), and dark green leafy vegetables (Table 4) were mostly consumed by adolescent girls than boys.

## Socio-demographic factors associated with dietary quality of adolescent girls and boys

From binary logistic regression (Table 6), none of the socio-demographic factors were significant predictors

**Table 4** Proportion of adolescents that consumed various food groups in the previous 24 h segregated by sex

| Food groups consumed | Girls | | Boys | | Overall (Boys and Girls) | | |
|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | *p*-value |
| Starchy staples | 182 | 93.8 | 127 | 86.4 | 309 | 90.6 | **0.020** |
| Legumes, nuts and seeds | 168 | 86.6 | 125 | 85.0 | 293 | 85.9 | 0.681 |
| Meat and fish | 57 | 29.4 | 38 | 25.9 | 95 | 27.9 | 0.471 |
| Organ meat | 24 | 12.4 | 13 | 8.8 | 37 | 10.9 | 0.300 |
| Eggs | 34 | 17.5 | 16 | 10.9 | 50 | 14.7 | 0.086 |
| Milk and milk products | 29 | 14.9 | 6 | 4.1 | 35 | 10.3 | **0.001** |
| Dark green leafy vegetables | 58 | 29.9 | 45 | 30.6 | 103 | 30.2 | 0.887 |
| Vitamin A rich fruits and vegetables | 70 | 36.1 | 38 | 25.9 | 108 | 31.7 | **0.044** |
| Other fruits and vegetables | 51 | 26.3 | 30 | 20.4 | 81 | 23.8 | 0.206 |

*n* number of participants, *P*-value significant at 0.05 level

**Table 5** Proportion of adolescents classified by the level of dietary diversity and the mean number of food groups consumed segregated by sex

| Number of food groups consumed | Level of dietary diversity | Girls Boys | | | | |
|---|---|---|---|---|---|---|
| | | n | % | n | (%) | *p*-value |
| < 4 | Low dietary diversity | 120 | 53.6 | 104 | 46.4 | 0.087 |
| ≥ 4 | High dietary diversity | 74 | 63.2 | 43 | 36.8 | |
| Mean number of food groups consumed | | (3.5 ± 2.1) | | (2.98 ± 1.8) | | |

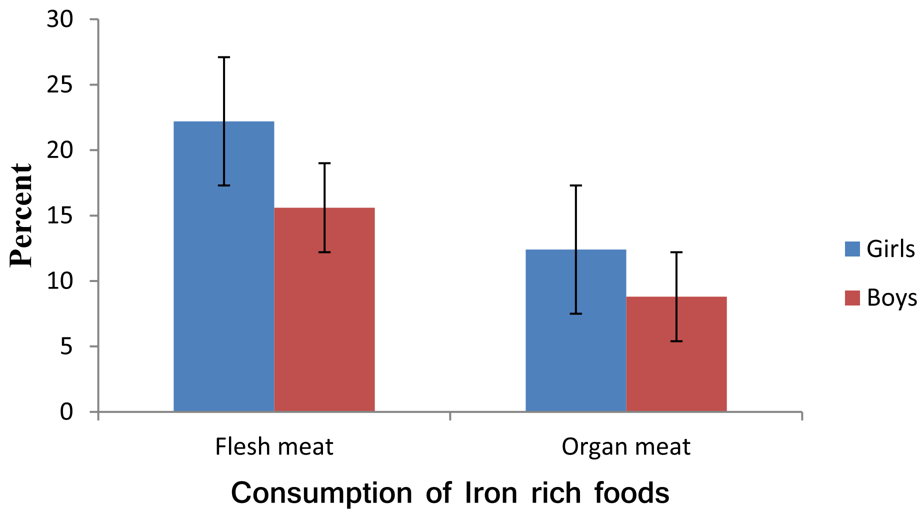


**Fig. 2** Proportion of adolescent girls and boys that consumed iron rich foods in the previous 24 h

**Table 6** Socio-demographic factors associated with dietary quality and micronutrient adequacy of adolescent girls and boys

| Socio-demographic factors | Girls | | Boys | |
|---|---|---|---|---|
| | B | *P*-values | β | *P*-values |
| Age of the respondent | -0.244 | 0.061 | -0.158 | 0.324 |
| Caretaker of the respondent | 0.235 | 0.569 | 0.304 | 0.523 |
| Class of the respondent | -0.466 | 0.195 | 0.208 | 0.633 |
| Highest level of education of the parent/guardian | -0.169 | 0.615 | 0.123 | 0.774 |
| Household size | 0.043 | 0.467 | 0.144 | 0.091 |
| Occupation of the parent/Guardian | 0.506 | 0.167 | -0.702 | 0.170 |
| Nature of the menstrual flow | 0.613 | 0.106 | | |
| Duration of menstruation (days) | -0.159 | 0.689 | | |
| Constant | -4.518 | 0.033 | -2.757 | 0.306 |

*P*-value significant at 0.05 levels; Girls (Pseudo R2 = 0.0920); Boys (Pseudo R2 = 0.0214) β: regression coefficients; Age (Continuous); Caretaker of respondent (Yes = 1, No = 0); Class of respondent dummy (Senior three = 1, Others = 0); Education level of parent/Guardian dummy (Primary = 1, Others = 0); Household size (Continuous); Occupation of parent/Guardian dummy (Peasant farmer = 1, Others = 0); Nature of menstrual flow dummy (Moderate = 1, Others = 0); Duration of menstrual flow dummy (Four days = 1, Others = 0)

Results for nature of menstrual flow and duration of menstruation are only applicable to girls

**Table 7** Socio-demographic factors that determine haemoglobin levels of adolescent girls and boys

| Socio-demographic factors | Girls | | Boys | |
|---|---|---|---|---|
| | B | P-values | β | *P*-values |
| Age of the respondent | -0.034 | 0.673 | 0.067 | 0.536 |
| Caretaker of the respondent | 0.332 | 0.200 | -0.164 | 0.637 |
| Class of the respondent | -0.279 | 0.200 | -0.009 | 0.976 |
| Highest level of education of the parent/guardian | **0.623** | **0.003** | 0.241 | 0.424 |
| Household size | -0.015 | 0.683 | 0.067 | 0.244 |
| Occupation of the parent/Guardian | 0.082 | 0.723 | -0.113 | 0.731 |
| Nature of the menstrual flow | **0.525** | **0.023** | | |
| Duration of menstruation (days) | -0.297 | 0.224 | | |
| Constant | 12.966 | 0.000 | 12.126 | 0.000 |

*P*-value significant at 0.05 levels; Girls (Pseudo R2 = 0.0920); Boys (Pseudo R2 = 0.0214) β: regression coefficients; Age (Continuous); Caretaker of respondent (Yes = 1, No = 0); Class of respondent dummy (Senior three = 1, Others = 0); Education level of parent/Guardian dummy (Primary = 1, Others = 0); Household size (Continuous); Occupation of parent/Guardian dummy (Peasant farmer = 1, Others = 0); Nature of menstrual flow dummy (Moderate = 1, Others = 0); Duration of menstrual flow dummy (Four days = 1, Others = 0)

Results for nature of menstrual flow and duration of menstruation are only applicable to girls

($p > 0.05$) of dietary diversity among adolescent girls and boys. Furthermore, results of linear regression (Table 7) of socio-economic and demographic factors, and Hb levels showed that only educational level of the parent/guardian and nature of menstrual flow among the adolescent girls were significant predictors ($p < 0.05$) of Hb levels. However, none of the other socio-economic and demographic factors significantly ($p > 0.05$) predicted Hb levels among the adolescents.

## Discussion

### The status of anaemia among the adolescents

Anaemia is a public health concern because it solely contributes to approximately 50% of the global anaemia cases [33, 40]. And adolescents are not excluded as they are highly susceptible to anaemia due to rapid growth spurt and onset of menstruation (particularly the girls), which consequently leads to increased nutrient demands [41]. In the present study, the average Hb level for the adolescent girls and boys in Gulu district was above the cut-off point established by WHO [39] (Table 3). This implies that generally, adolescents in the study areas had normal Hb level. However, the boys had significantly higher Hb levels ($p < 0.05$) than the girls (Table 3). This finding is similar to a study in India where the Hb level of rural boys was found to be higher than that of girls [42]. The finding of the current study further, agrees with previous studies [14, 15, 25, 43–46] that reported a higher prevalence of anaemia among adolescent girls than the boys. This could be attributed to the physiological differences between boys and girls, and is consistent with the girls' experience of menstruation (Table 2). It was acknowledged that girls lose blood monthly through menstruation [1, 16]. Our study suggests that adolescent girls are more prone than boys to irreversible negative effects of anaemia such as poor growth and cognitive function [1, 18], poor work performance [18], low immune system [1], neurological development disorders [19]. On the other hand, the prevalence of anaemia among the adolescent girls and boys in the current study (Table 3) was quite lower than the findings of the previous studies which involved both male and female adolescents as study participants [45]. Similarly, the findings of the present study also report a lower prevalence of anaemia among adolescent girls in the study area than in several other previous studies [10, 16, 19, 47–49]. Despite that, anaemia should not be underestimated because Acholi sub-region has the highest prevalence among women of reproductive age and children below five years of age [13]. It is against this background that efforts to address anaemia among adolescents should be considered on public health agenda in Gulu district and city in particular and Acholi sub-region in general although the prevalence still falls under mild category according to public health significance [39]. This is because mild anaemia was reported to have health consequences on the adolescent girls such as reproductive age; risk of low birth, preterm delivery, perinatal mortality, and postpartum haemorrhage [50]. Furthermore, although the results of the current study cannot be generalised to other parts of Uganda and the rest of the world, the findings of the current study still provide an important information that can give insight into a large-scale study and provoke mechanisms for addressing IDA.

### The status of dietary quality and dietary iron intake among adolescent girls and boys

Individual dietary diversity is defined as the type and number of food groups consumed by an individual over 24 h. It is reflective of an individual's ability to access a variety of foods and is a proxy of micronutrient adequacy [34, 51, 52]. Dietary diversity score (DDS) for adolescents were calculated based on 9 food groups [36]. Adolescents who consumed at least four (4) out of the 9 recommended food groups were categorized as having high dietary diversity whereas those who consumed less than four (4) food groups were categorized as having a less diversified diet. Based on our findings (Table 5), dietary diversity was not significantly different between girls and boys ($p > 0.05$), but girls consumed slightly more diverse diet than boys. Nonetheless, a high proportion of both adolescent girls and boys had low dietary diversity as assessed by the average number of food groups consumed (Table 5). The finding in the current study is not in agreement with previous studies [27, 53] that reported a low proportion of adolescents with low dietary diversity. In addition, the mean dietary diversity for the current study was lower compared to previous studies [53–55]. Low dietary diversity is associated with a high risk of micronutrient deficiencies such as anaemia [15, 25–27]. Therefore, low dietary diversity among both girls and boys suggests that school-going adolescents are at high risk of anaemia, which largely attributed to low levels of dietary intake.

Dietary iron, which is found in a wide range of foods is of two types, namely; haem and non-haem iron [56]. The difference stems from the way they are absorbed in the body. For instance, the bioavailability of haem iron is 2–6 times more than that of non-haem iron [57, 58]. This is due to the fact that haem iron is rapidly transported and absorbed intact into the mucosal cells of the small intestines where as non-haem iron is slowly absorbed because it is tightly bound to organic molecules in the form of ferric ($Fe^{3+}$) iron [59]. However, in the acidic medium of the small intestines, non-haem iron is reduced to the more soluble ferrous ($Fe^{2+}$) state of iron which is easily absorbed in the presence of ascorbic acid, citric acid and some amino acids [58–60]. Iron is found in great amounts in foods such as cereals, vegetables, beans, nuts, eggs, meat, fish and poultry [57, 61]. However, animal source foods such as eggs, meat, fish and poultry contain haem iron [56] whereas plant-based foods such as fruits, vegetables, beans and nuts contain non-haem iron [57, 62]. Absorption of dietary iron is often facilitated or hindered by three main factors which include; the quantity of iron, quality of iron, and the composition of diet [63]. For example, consumption of vitamin C-rich foods like tomatoes, citrus fruits and red, yellow and orange peppers in the diet aids in the absorption of non-haem iron in the body. However, regardless of the source of iron, there are other important micronutrients supplied in the diet that influence anaemia. For instance, inadequate vitamin B12 and folate leads to ineffective DNA synthesis and subsequent altered red blood cell formation, vitamin A impairs iron absorption and utilization, while zinc impedes iron absorption. However, anemia resulting from Vitamin A and Zinc intake [64].

The results (Table 4) further indicate that among the food groups, animal source foods (milk and its products, fish, meat, eggs and meat from animal organ), vitamin A rich fruits and vegetables, and other fruits and vegetables were the most consumed among girls compared to boys. Consumption of iron-rich foods (meat and fish, organ meat, dark green leafy vegetables) was also higher among adolescent girls than boys (Fig. 2; Table 4). Similarly, consumption of food groups such as starchy staples and legumes/seeds/nuts, was high amongst adolescent girls compared to the boys (Table 4). The findings of the present study with respect to adolescent girls is in agreement with [26, 53] who reported high consumption of plant-based diets dominated by starch staples (cereals, roots and tubers), but not with respect to consumption of animal source foods, fruits and vegetables as indicated in Table 4. More so, the present study indicates that there were significant differences in consumption of starchy staples, milk and its products and Vitamin A rich fruits and vegetables between the adolescent girls and boys ($p < 0.05$). This is in agreement with a previous study in India [65] among adolescents with regard to consumption of milk and meat, attributed to puberty, school enrolment, time use and dietary behaviours. Levin [66] also affirmed that consumption of fruits and vegetables was higher among girls than boys in Scotland. Consumption of a diversified diet, which is low in starchy staples and high in animal source foods is associated with both adequate macronutrient and micronutrient intake [36, 51, 52, 54], which consequently reduces the risk of nutritional deficiency diseases like iron-deficiency anaemia, rickets, and vitamin A deficiency [23, 38]. Consumption of plant-based foods more than animal-based foods among adolescent school-going children in our study reflects a potential risk to anaemia. This is because plant-based diets are associated with high levels of inhibitors that compromise iron bioavailability [67, 68]. This, coupled with physiological changes in adolescent such as menstruation in adolescent girls places them at a heightened risk of anaemia compared to the adolescent boys. It is therefore apparent that physiological conditions of adolescent girls simultaneous with insufficient intake of essential vitamins and minerals impact immune function, bone health, and overall growth and development [26]. In the Eastern Mediterranean Region (EMR), it was reported that malnutrition among adolescent has implications for health, which can be serious and wide ranging [69]. Consistent with this, the same authors [69] reported that iron deficiency was one of the leading determinants of adolescent disability-adjusted life years, especially in low- and middle-income countries, contributing to 20% of maternal deaths. In another study in India, females aged 15–49 years who appeared to have consumed nutrient-rich foods less frequently were twice more likely than men to suffer from anaemia, a non-communicable condition often caused by nutritionally inadequate diets [65]. Moreover, malnutrition among girls in their adult age or reproductive age is one of the causes a vicious cycle of undernutrition and poverty [70]. However, despite that fact that in the current study, the adolescent girls had better dietary quality than boys (Table 4), the prevalence of anaemia was significantly higher among the girls than boys (Table 3). First because, generally, that dietary diversity for both the adolescent girls and boys was low in the study area (Table 5). Secondly, women as well as adolescent girls are vulnerable to micronutrient deficiencies on account of their cyclical loss of iron during menstruation and childbearing [70]. Therefore, future interventions should focus on how to increase the number of foods that can be prepared and consumed by adolescents while at either school or home. Such interventions can include promotion of agricultural diversification, promotion of iron fortified and biofortified foods. In addition, there is need to investigate level of knowledge, awareness and attitude towards the consumption of iron-rich foods among adolescents. We also observed that adolescent girls had a better feeding pattern than their boy counterparts. This requires further investigation especially in the areas of food choices and preferences, eating behaviour and other related psycho-social issues.

### Socio-economic and demographic factors associated with dietary quality and anaemia among adolescent girls and boys

Previous authors [50] reported that differences in the magnitude of anaemia could be due to differences in economy, socio-culture, and dietary practices. In our study, socio-economic and demographic factors like age of respondent, caretaker of the respondent, class of the respondent, highest level of education of the parent/guardian, household size, occupation of the parent/guardian, nature of the menstrual flow (for girls only), and duration of menstruation (days) (for girls only) were considered and tested whether they had association with dietary quality. Interestingly, none of these socio-economic and demographic parameters showed significant relationship ($p > 0.05$) (Table 6). This therefore implies that dietary quality among the adolescent girls and boys in Gulu district is independent of the socio-economic and demographic factors stated above. Authors propose further research to uncover the factors influencing dietary quality among adolescents in Acholi subregion, particularly considering a longitudinal study design and qualitative approach. The findings of the present study are not consistent with previous studies [27, 53, 55, 71, 72] that reported socio-economic and demographic factors such as weak economic situation of households, maternal education, maternal employment, monthly income, staying with a single parent, educational level of adolescents as predictors of dietary diversity amongst adolescents.

For the prevalence of anaemia (Table 7), only education level of the parent/guardian and nature of menstruation were significant predictors of anaemia among the girls ($p < 0.05$). This could partly explain why Hb concentration of adolescent girls was below that of boys (Table 3) despite them consuming more animal food groups than boys (Table 4). The findings of the current study are in agreement with [45, 73] where education status of the parent/guardian was a positive predictor of anaemia. A highly educated parent/guardian is able to influence intake of micronutrient foods such as meat, fish, fruits and vegetables which consequently reduces the risk of anaemia amongst adolescents [16]. Furthermore, the results of the current study correlate with previous studies [73, 74] that reported menstruation as a predictor of anaemia amongst adolescent girls. Menstruation is associated with blood loss and hence reduces the iron stores in the body. Should there be no replacement of the lost iron, then anaemia manifests. Our study has shown that even with better levels of intake of animal products among adolescent girls than boys, adolescent girls were still prone to anaemia compared to boys whose diet was dominated by plant-based foods. Therefore, preventing anaemia among adolescents should take into consideration strengthening the already existing health interventions at schools such as regular deworming and timely diagnosis and treatment of malaria. In addition, consideration should be given to iron supplementation programs to adolescent girls in order to reduce anaemia, heighten malaria control programs and health and nutrition education. Further study is required to understand the effect of iron supplementation and its cost-effectiveness, health and nutrition promotion among adolescents.

The major limitation of the current study is that the use of HaemoCue has been reported to overestimated the Hb concentration [75, 76]. However, the current study provided an important insight into iron deficiency anaemia because most of the anaemia in developing countries is due to iron deficiency [29, 31, 75] resulting from inadequate diet [23, 24] Therefore, future studies can consider using a gold standard for assessing iron status, like measurement of circulating transferrin receptor in healthy individuals alongside Hb measurement which is a proxy for assessing the prevalence of iron deficiency anaemia [75].

## Conclusions

This study investigated the status of anaemia, dietary quality and their socio-economic and demographic predictors among adolescents. The present study has demonstrated that the prevalence of anaemia was high among adolescent girls than among the boys. Dietary quality was low among both adolescent girls and boys. Consumption of animal source foods, vitamin A rich fruits and vegetables, and other fruits and vegetables was higher among girls compared to boys. Adolescent girls had better intake of dietary iron than the boy counterparts. Dietary quality was independent of socio-economic and demographic factors among adolescent girls and boys. The level of education attainment by the parent/guardian and nature of the menstrual discharge were the main predictors of anaemia amongst girls.

We recommend interventions by both health and agricultural-related practitioners to strengthen activities in rural schools such as health and nutrition education to create awareness about dietary diversity and promotion of agricultural practices such as school vegetable gardens, orchards poultry production and rearing of small ruminants to support consumption of diverse foods in schools with the view of reducing the burden from iron deficiency anaemia.

### Abbreviations

| | |
|---|---|
| FAO | Food and Agricultural Organization |
| Hb | Haemoglobin |
| ICF | Inner City Fund |
| IDA | Iron Deficiency Anaemia |
| IDDS | Individual Dietary Diversity Score |
| IDDSQ | Individual Dietary diversity Score Questionnaire |
| SPSS | Statistical Package for Social Scientists |
| UBOS | Uganda Bureau of Statistics |

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### Authors' contributions

GA: Conception and design, data collection, analysis and interpretation, drafting of the manuscript SMO: Conception and design, analysis and interpretation, drafting of the manuscript GO: Conception and design, analysis and interpretation, drafting of the manuscript, Final approval for publication CM: Critical review of the draft manuscript.

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### Data availability

The data that support the findings of this study are available from the authors but restrictions apply to the availability of these data, and so are not publicly available. Data are, however, available from the authors upon reasonable request and with permission from the authors.

## Declarations

### Ethics approval and consent to participate

Ethical clearance to conduct this study was obtained from the Gulu University Research Ethics Committee (GUREC) (No. GUREC-052–19) at Gulu University, Gulu City. GUREC was officially recognized with full accreditation bestowed by the Uganda National Council for Science and Technology (UNCST) in 2015. Furthermore, the committee earned accreditation from the Office for Human Research Protections (OHRP) in the United States, with the designation IRB No. IRB00010381. Administrative clearance was also obtained from the Chief Administrative Officer (CAO) of Gulu district and the school administration. Informed consent was obtained from all the adolescents 18 years and above, and from the parents/legal guardians for adolescent younger than 18 years.

### Consent for publication
Not applicable.

### Competing interests
The authors declare no competing interests.

### Author details
[1]Faculty of Agriculture and Environment, Department of Food Science and Postharvest Technology, P.O. Box 166, Gulu, Uganda. [2]Faculty of Medicine, Gulu University, P.O. Box 166, Gulu, Uganda. [3]Department of Food Science and Postharvest Technology, Faculty of Agriculture and Environment, Gulu University, P.O. Box 166, Gulu, Uganda.

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## Publisher's Note



**Gloria Adokorach** Contribution: Conception and design, data collection, analysis and interpretation, drafting of the manuscript.

**Sunday Mark Oyet** Contribution: Conception and design, data collection, analysis and interpretation, drafting of the manuscript.

**Gerald Obai** Contribution: Conception and design, analysis and interpretation, drafting of the manuscript, Final approval for publication.

**Christopher Muggaga** Contribution: Critical review of the draft manuscript.