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Original Research Article

Prevalence and associated risk factors of iron deficiency without anemia among school adolescents in Mbouda, Western Cameroon

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ABSTRACT

Background: Adolescents are a particularly vulnerable age group to iron deficiency without anemia (IDWA). This study aimed at determining the prevalence and associated risks factors of IDWA among apparently healthy school teenagers in Mbouda, West-Cameroon.
Methods: The 778 blood samples were randomly collected from adolescents aged 10-19 years of four schools in Mbouda. Appropriate indicators including haemoglobin and haematocrit, serum iron, ferritin, transferrin, and total iron binding capacity, transferrin saturation were determined using standard methods.
Results: The overall prevalence of IDWA was 40.4%. High significant difference in the mean values of serum iron ($p \leq 0.001$), serum ferritin ($p \leq 0.001$), TIBC ($p=0.007$), CST ($p \leq 0.001$) were observed in participants with IDWA compared to those without IDWA. The sociodemographic risk factors of IDWA in school adolescents were school site ($p=0.022$; 0.14 (0.90-1.43) and period of menstruation ($p=0.015$; 1.48 (1.083-2.03). Consumption of roots-tubers [OR: 0.92 (0.48-1.77)] legumes [OR: 2.65 (1.91-3.67)], cereals [OR: 0.90 (0.67-1.22)], increased the risk of IDWA while consumption of vegetables [OR: 0.29 (0.22-0.39)], eggs [OR: 0.66 (0.49-0.90)], and fish-shrimp [OR: 0.172 (0.10-0.295)] decreased the risk of IDWA. Meal consumption frequency had a statistically significant association with IDWA ($p \leq 0.001$).
Conclusions: This study identified that IDWA was a major public health in adolescents. This study will help in planning and implementation of the policy for prevention of IDWA in adolescents.

Keywords: IDWA, School adolescents, Blood parameters, Dietary habit, Cameroon

INTRODUCTION

Iron deficiency without anemia (IDWA) is the predominant form of iron deficiency (ID), a nutrition related health problem that is commonly encountered in the world.[1] Worldwide, there are approximately 1 billion cases of IDWA.[1] IDWA frequently remains undiagnosed when symptoms are attributed to iron deficiency anemia (IDA) and is poorly recognised by clinicians despite its high prevalence.[2] Adolescent children are one of the major risk groups for iron deficiency.[3] The prevalence of IDWA is unknown although it has been suggested that it can be twice that of IDA.[4] In developed countries, 8% to 20% of adolescent girls are thought to be iron deficient.[5] Several studies such as Demographic Health Surveys indicated high prevalence of anemia in Cameroon mainly due to iron deficiency. For instance, 51.41% of iron deficiency among children aged 0 to 24 months in 6 health centers in the rural community of Bangang in western Cameroon, 21.36% of iron deficiency anemia among pregnant women aged 17 to 36 at the CHUY in Cameroon, 57%, 41.7% and 40% of anemia nationally,

respectively among children aged 6-59 months, adolescent girls aged 15-19 years and Cameroonian women aged 15 to 49.[6,7] 33.8% of women aged 15 to 49 years are anemic in Western Cameroon mainly due to iron deficiency.[8] Moreover, 1.1% of households suffer from severe to very severe hunger in Cameroon with prevalence above 20%, the West is one of the regions most affected by food insecurity in September 2020 with a prevalence of 20.5%, resulting mainly from an inadequate food consumption, that affects 18.7% of households are affected.[9] Despite the multiple consequences of IDA and IDWA in adolescents, few investigations were conducted among adolescents in Cameroon in general an in Mbouda in particular. Therefore, this study was undertaken to estimate the prevalence and associated risk factors of IDWA among 10-19 years school adolescents in Mbouda.

METHODS

Study design

This was cross sectional study conducted from September 2018 to December 2020, in order to assess prevalence and risk factors of IDWA among apparently healthy school adolescents in Mbouda, Western region of Cameroon.

Inclusion criteria and study participants

Were included in the study of adolescent girls and boys (10 to 19 years old); not showing clinical signs of anemia, having freely agreed to participate in the study, whose parents have consented to participate in writing. Adolescents with sickle cell disease and those with pathologies such as malaria and intestinal parasitosis were not included. The present study includes 778 school adolescents aged 10-19 years randomly selected from four schools in Mbouda.778 blood samples were collected.

Data collections

Data were collected using a pretested structured questionnaire. The methods of 24-hour recall and the meal consumption frequency per day were used according to FAO/INFOODS food composition Table for Western Africa (WAFCT) criteria.[10]

Five ml of venous blood were taken from each student to measure hemoglobin (Hb), serum iron (SI), serum ferritin (SF), and transferrin ROCHE diagnostic kits. Transferrin Saturation coefficient (TSC) and total iron binding capacity by transferrin (TIBC) were determined by calculation from transferrin according to WHO and CDC criteria.[11] Two higher diploma nurses were recruited to confirm the physical health status as well as history disease of each participant and 3 higher diploma laboratory technicians for data collection. The adolescents were declared anemic or not according to WHO criteria.[12] IDWA was defined according to WHO criteria.[13,14]

Ethical approval

The national ethics committee of Cameroon (Ref no. 2018/08/1086/CE/CNERSH) approved experimental procedures and protocols used in this study. In addition, authorizations from the Bamboutos secondary education divisional delegate and that of the head of district health centre of Mbouda were obtained.

Statistical analysis

Data were analyzed using SPSS version 18.0 statistical software. Odds ratio (OR) with their 95% confidence level (CI) were calculated. Descriptive statistics of continuous and discontinuous variables were expressed as Mean ± SD and percentage, and compare with chi-square test and student t test respectively. $P<0.05$ was considered as statistically significant.

RESULTS

Prevalence of IDWA among school adolescents.

A total number of 778 blood samples were screened for IDWA. Table 1 shows the overall prevalence of IDWA by age and gender: 40.4% of adolescents (n=314) were found iron deficient without anemia, of whom 42.6% (n=55) were males and 39.9% (n=259) were females, therefore, IDWA was more prevalent in male adolescents than female adolescents. Concerning age groups, almost 40.8% (n=146) of adolescents aged 10-12 years were found IDWA compared to 40.0% (n=168) for adolescents 13-19 years old; therefore, the prevalence of IDWA did not varies according to age group. Higher prevalence of IDWA was found among female adolescents 13-19 years old 56% (n=145) compared to male adolescents 13-19 years old 44% (n=114) but this difference was not significate (p=0.936). Therefore, IDWA increased with age in female and decreased with age in male as indicated (Table 1). Regarding the adolescents without IDWA, globally, female was slightly more represented 51.45% (n=252) than male 48.5% (n=212). According to age groups males 10-12 years were slightly more represented 52.7% (n=39) than males 13-19 years 44.4% (n=173) while in the other hand, females 13-19 years were more represented 55.6% (n=217) than females 10-12 years 47.3% (n=35). Considering the variable related to residence area, we observed a non-significant difference between males and females with IDWA respectively in rural (p=0.411) and urban area (p=0.862). IDWA was more prevalent among male 51.2% (n=43) than females 48.8% (n=41) in rural while in the other hand, females were more prone to IDWA 55.2% (n=127) than males 44.8% (n=103) in urban. According to the site or school, a non-significant difference was found between males and females with IDWA in all the schools. The highest prevalence of IDWA for females is observed in HS Bamenkombo 61.5% (n=16) and the lowest in THS Bamendjo 43.1% (n=25). For males, highest prevalence of IDWA was found in THS Bamendjo 56.9% (n=33) and

the lowest in HS Bamenkombo 38.5% (n=10). Coming to the level of knowledge about iron deficiency, a non-significant difference between male and female with IDWA was found. IDWA was distributed in adolescents independently of gender, level of knowledge and moreover between adolescents with IDWA and those without IDWA.

Table 2 presents mean values of biochemical parameters according to IDWA status. As we can see, serum iron, TIBC, serum transferrin, serum ferritin, TSC were significantly lower in participants with IDWA compared to participants without IDWA. Similarly, mean value of haemoglobin was also lower in participants with IDWA compare to participants without IDWA but the difference was not significate (p=0.220), interestingly, these values were normal independently of the IDWA status.

Risk factors enhance the prevalence of IDWA among school adolescents

Table 3 below shows multivariate analysis of sociodemographic risk factors of iron IDWA among the sample. From all the variables indicated, only school site (p=0.022; 0.14 (0.90-1.43) and period of menstruation (p=0.015; 1.48 (1.083-2.03) had a statistically significant association with IDWA at 95% significance level. BHS Mbouda was at 0.22 (0.01-3.30), while that of THS Bamendjo was at 0.95 (0.87-1.04). THS Mbouda was redundant. All the other variables in this comparison such as sex (p=0.623), age (p=0.826), residence area (p=0.295), knowledge on iron deficiency (p=0.472), profession (p=0.448) and family size (p=0.505) did not have any statistically significant association with IDWA. As residence area is concern, adolescents residing in urban were more prone to IDWA 230 (41.6%) than those in rural 84 (37.3%). Considering the variable related to family size and number of children, we observed that adolescents were more prone to IDWA if they lived in households with more than five residents 45.33% (n=34) than family's with less than five residents' members 40.5% (n=101). Concerning the level of knowledge about iron deficiency, IDWA was more represented in adolescents with poor knowledge 41.6% (n=241) than those with good 36.7% (n=58) or those with very good knowledge 36.6% (n=15). Coming to the duration of menstruation, adolescent girls whose period of menstruation was equal or more than five days were more prone to IDWA 43.3% (n=230) than those with less than five days 34.0% (n=84).

Dietary habit risk factors of IDWA among school adolescents.

Table 4 below presents binary analysis of food groups consumed as risk factors of IDWA. As we can see, vegetable with a p value, OR and CI value of (p≤0.001), 0.29 (0.22-0.39); fruits (p≤0.001), 0.316 (0.227-0.439); legumes (p≤0.001), 2.65 (1.91-3.67); meat-poultry (p≤0.001), 0.265 (0.18-0.388); eggs (p=0.009), 0.66 (0.49-0.90); dairy products (p≤0.001), 0.476 (0.34-0.67); fats (p≤0.001), 0.135 (0.05-0.40); fish-shrimps (p≤0.001), 172 (0.10-0.295); nuts-seeds (p≤0.001) 0.429 (0.31-0.59) all had a statistically significant association with IDWA in this study at 95% confidence interval. Only cereals (p=0.537), 0.90 (0.67-1.22); root-tubers (p=1.000), 0.92 (0.48-1.77); and drinks-sauces-spices-condiments (p=0.426), did not have a statistically significant association with IDWA. It emerges from the table that the ten food groups regularly consumed were fats, drinks-sauces-spices-condiments, fish-shrimp, cereals, vegetables, fruits, nuts-seeds, roots-tubers, eggs and legumes. As we can see, meat-poultry and dairy products were not part of the ten first groups. Therefore, IDWA was more prevalent when adolescents consumed fats (37.9%), drinks-Sauces- spices-condiments (28.9%), nuts and seeds (27.55%), cereals (26.1%), legumes (15.2%), roots-tubers (14.3%), vegetables (12.3%), eggs (11.7%) and less prevalent for those who consumed fruits (8.40%), dairy products (7.7%); meat-poultry (5.1%), fish-shrimp (2.7%). Meal consumption frequency per day had a statistically significant association with IDWA at 0.05 significance level.

Table 5 presents the meal consumption frequency of participants per day. As we can see, meal consumption frequency had a statistically significant association with IDWA (p≤0.001) at 0.05 significance level. The majority of the respondents (70.4 %) had meal frequency of 1- 2 times per day with IWDA prevalence of 35.2 % out of 40.4%. Adolescent having good consumption frequency (3 meals/day and over) are more protected of IDWA (5.1%) than those with weak consumption (10.8 %) and fairly good meal frequency consumption per day 24.4%.

Table 1: Prevalence of IDWA according to age and gender among school adolescents.

Parameters		Adolescents without IDWA				Adolescents with IDWA				P value
		Male		Female		Male		Female		
		N	(%)	N	(%)	N	(%)	N	(%)	
Age (years)	**10-12**	39	52.7	35	47.3	32	58.2	23	41.8	0.593
	13-19	173	44.4	217	55.6	114	44.0	145	56.0	0.936
Residence area	**Rural**	64	45.4	77	54.6	43	51.2	41	48.8	0.411
	Urban	148	45.8	175	51.2	103	44.8	127	55.2	0.862
Level of knowledge about iron deficiency	**Good**	40	40	60	60	29	50	29	50	0.247
	Poor knowledge	160	47.3	178	52.7	109	45.2	132	54.8	0.673
	Very good	12	46.2	14	53.8	8.0	53.3	7.0	46.7	0.751

Continued.

Parameters		Adolescents without IDWA				Adolescents with IDWA				P value
		Male		Female		Male		Female		
		N	(%)	N	(%)	N	(%)	N	(%)	
Site (school)	HS Bamenkombo	24	36.4	42	63.6	10	38.5	16	61.5	1.000
	BHS Mbouda	86	42.8	115	57.2	52	41.3	74	58.7	0.819
	THS Bamendjo	40	53.3	35	46.7	33	56.9	25	43.1	0.727
	THS Mbouda	62	50.8	60	49.2	51	49.0	53	51.0	0.894

*Statistically significant at 0.05 significance level; BHS: Bilingual high school, HS: High school, THS: Technical high school. Poor knowledge=Validation of zero to three evaluation criteria; Good knowledge=Validation of at least four evaluation criteria; Very good knowledge=Validation of more than four evaluation criteria. (TB), n=778.

Table 2: Mean values of biochemical parameters according to IDWA among school adolescents.

Parameters	Status of IDWA		P value
	Yes	No	
Serum iron (mg/l)	0.35±0.203	0.85±0.307	≤0.001*
TIBC (mg/l)	4.58±0.882	4.76±1.116	0.007*
Serum transferrin (g/l)	3.28±0.632	3.41±0.800	0.007*
Hematocrit (%)	40.60±5.203	42.63±5.088	0.290
Hemoglobin (g/dl)	13.47±1.715	14.20±1.665	0.220
Serum ferritin (µg/l)	38.73±22.249	78.25±41.565	≤0.001*
TSC (%)	7.99±4.505	18.39±6.761	≤0.001*

*Statistically significant at 0.05 significance level; TIBC: total iron binding capacity; TSC: transferrin saturation coefficient.

Table 3: Multivariate analysis of sociodemographic risk factors of IDWA among school adolescents.

Variables		Total	IDWA, n (%)		P value	OR (95%CI)
			Yes	No		
Age (years)	10-12	358	146 (40.8)	212 (59.2)	0.826	1.03 (0.78-1.37)
	13-19	420	168 (40.0)	252 (60.0)		1
Sex	Male	129	55 (42.6)	74 (57.3)	0.623	0.89 (0.61-1.31)
	Female	649	259 (39.9)	390 (60.0)		1
Residence area	Rural	225	84 (37.3)	141(62.6)	0.295	1.19 (0.87-1.64)
	Urban	553	230 (41.6)	323 (58.4)		1
Level of knowledge about iron deficiency	Good knowledge	158	58 (36.7)	100 (63.2)	0.472	0.30 (0.10-1.20)
	Poor knowledge	579	241 (41.6)	338 (58.4)		0.24 (0.13-1.09)
	Very good knowledge	41	15 (36.6)	26 (63.4)		1
Site (school)	HS Bamenkombo	92	26 (28.2)	66 (71.8)	0.022*	0.14 (0.90-1.43)
	BHS Mbouda	327	126 (38.5)	201 (61.47)		0.22 (0.01-3.30)
	THS Bamendjo	133	58 (43.6)	75 (56.4)		0.95 (0.87-1.04)
	THS Mbouda	226	104 (46.0)	122 (54.0)		1
Profession	Farmer	224	91 (40.6)	133 (59.37)	0.448	1.047 (0.93-1.18)
	Others	56	27 (48.2)	29 (51.8)		0.86 (0.58-1.28)
	Trader,	248	102 (41.1)	146 (58.9)		0.22 (0.16-2.31)
	Civil Servant	211	76 (36.0)	135 (63.4)		0.95 (0.40-2.01)
	Unemployed	39	18 (46.15)	21 (53.8)		1
Family size	≤ 5 [1-5] members	249	101 (40.5)	148 (59.4)	0.505	1.22 (0.72-2.04)
	>5 [6 and more] members	75	34 (45.33)	41 (54.6)		1
Period of menstruation (Days)	<5	247	84 (34.0)	163 (66.0)	0.015*	1.48 (1.083-2.03)
	≥5	531	230 (43.3)	301 (56.7)		1

*Statistically significant at 0.05 significance level; BHS: Bilingual high school, HS: High school, THS: Technical high school. Poor knowledge=Validation of zero to three evaluation criteria; Good knowledge=Validation of at least four evaluation criteria; Very good knowledge=Validation of more than four evaluation criteria. (TB).

Table 4: Binary analysis of dietary habits as risk factors of IDWA.

Variables		Total	IDWA, N (%)		P value	OR (95%CI)
			Yes	No		
Cereals	No	264 (33.9)	111 (14.3)	153 (19.6)	0.537	0.90 (0.67-1.22)
	Yes	514 (66.1)	203 (26.1)	311 (40.0)		1
Root-tubers	No	504 (64.8)	203 (26.1)	301 (38.8)	1.000	0.92 (0.48-1.77)
	Yes	274 (35.2)	111(14.3)	163 (19.9)		1
Vegetable	No	404 (51.9)	218 (28.0)	186 (23.9)	≤0.001	0.29 (0.22-0.39)
	Yes	374 (48.1)	96 (12.3)	278 (37.8)		1
Fruits	No	503 (64.7)	210 (27.0)	254 (32.7)	≤0.001	0.316 (0.227-0.439)
	Yes	275 (35.4)	65 (8.40)	249 (32.0)		1
Legumes	No	574 (73.8)	196 (25.2)	378 (48.6)	≤0.001	2.65 (1.91-3.67)
	Yes	204 (26.2)	118 (15.2)	86 (11.0)		1
Meat-poultry	No	573 (73.7)	274 (35.2)	299 (38.5)	≤0.001	0.265 (0.18-0.388)
	Yes	205 (26.3)	40 (5.1)	165 (21.2)		1
Eggs	No	510 (65.6)	223 (28.7)	287 (36.9)	0.009	0.66 (0.49-0.90)
	Yes	223 (34.4)	91 (11.7)	177 (22.8)		1
dairy products	No	564 (72.5)	254 (32.6)	310 (39.8)	≤0.001	0.476 (0.34-0.67)
	Yes	214 (27.5)	60 (7.7)	154 (19.8)		1
Fats	No	23 (3.0)	19 (2.5)	4 (0.5)	≤0.001	0.135 (0.05-0.40)
	Yes	755 (97.0)	295 (37.9)	460 (59.1)		1
Drinks-sauces-spices-condiments	No	234 (30.1)	89 (11.4)	145 (18.6)	0.426	1.15 (0.84-1.57)
	Yes	544 (69.9)	225 (28.9)	319 (41.0)		1
Fish-shrimps	No	244 (31.4)	47 (6.0)	197 (25.4)	≤0.001	0.172 (0.10-0.295)
	Yes	533 (68.6)	21 (2.7)	512 (65.9)		1
Nuts-seeds	No	454 (59.6)	241 (46.1)	272 (53.02)	≤0.001	0.429 (0.31-0.59)
	Yes		73 (27.55)	192 (73.45)		1

Table 5: Multivariate analysis of meal consumption frequency per day as risk factors of IDWA.

Variables		Total	IDWA, N (%)		P value	OR (95%CI)
			Yes	No		
Meal consumption Frequency	Weak	105 (13.5)	84 (10.8)	21 (2.7)	≤0.001	0.81 (0.61-1.42)
	Fairly good	443 (56.9)	190 (24.4)	253 (32.5)		0.476 (0.34-0.67)
	Good	230 (29.6)	40 (5.1)	190 (24.5)		1

1 meal/day=weak (W); 2 meals/day=Fairly good (FG); 3 meals/day and over=Good (G).

DISCUSSION

The present study was conducted to investigate the prevalence of IDWA among school teenagers in Mbouda Western Cameroon. We found that the overall prevalence of IDWA in our study population of adolescents aged 10-19 years was 40.4%. IDWA can be classified as a major public health problem in this population according to the WHO established criterion**.** Nationally, studies relative to adolescents as far as iron deficiency is concerned is scars in Cameroon, compared to the prevalence of 51.1% reported by Kana and al among children under 24 months in Bangang neighboring Mbouda, this prevalence is low. However, internationally, our findings is consistent with that of Balcı et al in Turkey with a prevalence of 41% of iron deficiency among adolescents 12-16 years and that of Best et al who obtained the prevalence of 43% among school age children in West Pacific.[15,16] Differences in the study areas, methodologies used in these studies, cultural variations, sample sizes, lifestyles, socio-economic, dietary habits and other pathological or genetic factors could also be responsible for the observed variation.

The sociodemographic risk factors of IDWA in school adolescents were also evaluated, and we found that school site had a statistically significant association with IDWA at 95% significance level. In the western region of Cameroon eating habits varied from one village to another and this could explain the differences observed. In addition, several factors that are associated with pathophysiological mechanisms of iron deficiency coincide in adolescents to give rise to increased nutritional requirements, e.g., the adolescent physical activity and growth spurt. It has been demonstrated that, iron requirements vary a lot depending with the age, birth conditions and, of course, the weight, sex and size of the child.[17] We found that IDWA was slightly more prevalent among male adolescents 42.6% than female adolescents 39.9% but the difference was not statically significant (p=0.623). Murti Andriastuti et al also found iron

deficiency more prevalent among males than females in a study with children age group (6-9 years old), which included 21 females (46.7 %) and 24 males (53.3 %) in Indonesia.[16]

Multivariate analysis among the sample showed that, older adolescents were more vulnerable to iron deficiency than younger adolescents were. Moreover, increase in iron requirement among adolescents peaks between the ages of 14-15 years for girls and one to two years later for boys.[18] In addition, 41.6% of the female reported to have been menstruating already while 44.7% were not yet menstruating; the differences may be due to the larger number of non-menstruating adolescents (females) in the early adolescent group compared to the older one. Higher prevalence of IDWA was found among female adolescents 13-19 years old 56% compared to male adolescents 13-19 years old 44% but this difference was not significant. Iron requirements in girls begin to increase after menarche, with 30-40 mL of blood loss during each menstruation cycle leading to a loss of 15-30 mg of iron per cycle.[19] In adolescent girls, this deficiency situation is favoured by insufficient consumption of meat, or even adherence to a lacto-vegetarian diet.[20] This idea is reinforced by an European study in adolescents showing that not only iron intakes are significantly lower in adolescent girls than in adolescent boys (11 mg versus 14 mg/day), but the ratio of haem iron/non-haem iron intakes was not satisfactory, only in 27.6 % of girls compared to 86.3 % of boys.[20]

Dietary habit risk factors of IDWA among school adolescents was studied. Vegetable, fruits, legumes, meat-poultry, eggs, dairy products, fats, fish-shrimps, nuts-seeds all had a statistically significant association with IDWA in this study at 95% confidence interval. Only cereals, root-tubers, and drinks-sauces-spices-condiments, did not have a statistically significant association with IDWA. The prevalence of IDWA according to food consumption frequency among the ten first food groups regularly consumed in decreasing order were fats, drinks-sauces-spices-condiments, fish-shrimp, cereals, vegetables, fruits, nuts-seeds, roots-tubers, eggs and legumes. Meat-poultry and dairy products were not part of the ten first groups. Consumption of roots-tubers, legumes, cereals, nuts-seeds, drinks-sauces-spices-condiments, fats, increased the risk of IDWA whereas consumption of vegetables, eggs, fruits, dairy products, meat-poultry and fish-shrimp decreased the risk of IDWA. Iron deficiency is due to inadequate intake or malabsorption of dietary iron. The adequacy of dietary iron depends on the intake and the bioavailability, which in turn are contingent to the nature of the food and the composition of the overall diet. In developing countries, the amount of iron in the diet is usually enough to cover body needs, because it is mainly provided by plant (cereals, tubers) based food in the form of non-haem iron, its bioavailability is very low.[21] The low iron content, the lack of other iron rich food, and increased iron requirements due to high growth rate predispose teenagers to the depletion of iron stores. In addition, the major components of the adolescent's diet in Mbouda are fats, drinks-sauces-spices-condiments, nuts-seeds, cereals, legumes, roots-tubers; vegetable which are not favourable for iron absorption and which contain inhibitors of iron absorption as compared to meat or fish. This result is consistent of that of global food security and vulnerability analysis in Cameroon that reported that 10.3% of households in the West region of Cameroon, or 72.000 people representing 7.3% of households are food unsecured in the West in 2011.[22] In the same vein, national survey on food and nutrition security in Cameroon reinforce this idea by asserting that food insecurity results mainly from inadequate food consumption in Cameroon and affects 10.7% of its population. The West with a prevalence of 20.5% is among the regions that are most affected by food insecurity in September 2020 and is particularly concerned by the low consumption of foods rich in iron (15.9%).[9] Moreover, our findings revealed that our participants who consumed nut and seed are more prone to IDWA with a prevalence of 27.55%. In fact, nut and seed are rich in plants proteins. Several studies have shown that the presence of plant proteins significantly inhibits the absorption of non-haem iron.[23] This effect is mainly due to phytates bound to these proteins, but has also been attributed to high molecular weight peptides.[24] Iron absorption inhibitors like phytates are found in bread, wheat bran, breakfast cereals, oats, and rice. Other iron absorption inhibitor like tannins or polyphenols are found in tea, coffee, cocoa, and certain vegetables while calcium is found in milk and cheese.[25] Vegetables and legumes including beans, peas and lentils, are great sources of iron, but they contain tannins or polyphenols, which are iron absorption inhibitors.[26]

The limitation of this study lies in the fact that, we did not obtain data about additional blood parameters such as blood count or serum levels of folate and vitamin B12, reticulocyte count, C-reactive protein (CRP) test or *Helicobacter* (*H. pylori*) which would have allowed us to distinguish between different causes of IDWA. Future studies should consider including this information in order to further characterized IDWA in this population and identify appropriate treatment strategies.

CONCLUSION

The result of this study indicated that the overall prevalence of IDWA among adolescents in the study areas was 40.4%. This study revealed that, vegetable, fruits, legumes, meat-poultry, eggs, dairy products, fats, fish-shrimps, nuts-seeds had a statistically significant association with IDWA in adolescent. Early adolescent (10-12) years were found to be more IDWA than older adolescents were 13-19 years, thus, stronger studies with better designs need to be conducted to confirm this finding and to come up with concrete evidence for policy making.

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