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Prevalence of Iron Deficiency Anaemia and Associated Factors Among Resident Students on the Gaston Berger University Campus in Saint-Louis

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Abstract: Iron deficiency anaemia is the most common micronutrient deficiency in the world. The most vulnerable groups are children, adolescents and pregnant women. Several studies carried out in Senegal have confirmed a high prevalence of anaemia among these vulnerable groups. However, there are few data on the prevalence of anaemia in students whose diet quality is often decried. The objective of this study was to determine the prevalence of iron deficiency anaemia among resident students at the Gaston Berger campus in Saint-Louis and the associated factors. The study took place on the campus of the Gaston Berger University of Saint-Louis (CROUS) and the Centre for Research and patient ambulatory Management of Sickle Cell Disease (CERPAD). This was a cross-sectional descriptive epidemiological survey with an analytical aim which lasted from June 3 to July 2, 2021. A questionnaire was administered to collect epidemiological, health and biomedical data. The haemoglobin level made it possible to define and classify the severity of anaemia. Binary logistic regression was used to assess the association between these factors and anaemia. A significance threshold was set from a $p < 0.05$. Due to the impact of anaemia on physical growth, cognitive development, reproduction and physical work capacity, awareness and screening strategies should be encouraged to ensure early detection and implementation of a supplementation program.

Keywords: Iron Deficiency, Students, Associated Factors, Campus, UGB

1. Introduction

Anaemia is defined by the World Health Organization (WHO) as one of the ten most serious health problems of the modern world that affect people in rich and poor countries [1]. The WHO estimates that two billion people worldwide suffer from anaemia. It is the most common form of micronutrient deficiency in the world [2]. These consequences affect both the health of populations and the economic and social development of countries [2]. Anaemia affects all population groups. However, pregnant women and young children are the most susceptible groups. In its

severe form, it is associated with fatigue, weakness, dizziness and drowsiness. Without treatment, anaemia can worsen and become an underlying cause of chronic poor health [3]. The causes of anaemia are multiple but it is reported that about 50% of cases are due to iron deficiency [4]. Several studies conducted in Senegal have confirmed this high prevalence among vulnerable groups [5, 6]. However, there are no data on the prevalence of anaemia and iron deficiency in students, the majority of whom are young people whose diet is often decried. It is for this reason that we are proposing to conduct such a study with the general objective of determining the prevalence of iron deficiency anaemia among resident students within the Gaston Berger campus in Saint-Louis and the associated factors. The resulting specific objectives were:

1) assess the overall prevalence of anaemia in the student population;
2) identify the main types of anaemia;
3) study the associated factors: age, sex, eating habits, level of study;
4) make recommendations.

2. Methodology

2.1. Study Framework

The study took place on the campus of the Gaston Berger University of Saint-Louis (CROUS), the Centre for Research and Patient Ambulatory Management of Sickle Cell Disease (CERPAD) which was created in 2013 thanks to the agreement between Gaston Berger University (UGB) in Saint-Louis and the Pierre Fabre Foundation. It is the first centre dedicated to neonatal screening and research on sickle cell disease in Senegal. This centre has a multi-purpose laboratory and was responsible for processing samples and analysing biological data.

2.2. Type of Study

The study population consisted exclusively of students residing on the Gaston Berger University campus in Saint-Louis and regularly enrolled in one of the eight Training and Research Units. A questionnaire was administered to collect epidemiological, health and biomedical data.

Blood samples were taken by CERPAD technicians during the period ranging from June 3 to July 2, 2021 at the student medical service. The samples were sent to CERPAD for processing and assaying of the targeted parameters.

2.3. Sampling Method

We used the cluster sampling method. Indeed, we went door to door in all the villages of the university campuses (I and II) to inform the students about the object of our study. All the volunteers registered on our census forms and a questionnaire was delivered to each of them with a summons after one week to the student medical centre to collect blood samples.

2.4. Sample Size

The formula used to calculate the sample size was:

$$n = \frac{t_p^2 \text{ x } P(P-1) \text{ x } N}{t_p^2 \text{ x } P(P-1) + N \text{ x } y^2}$$

With:

n: sample size; N: size of the target population; t_p^2: quantile of the normal law;

P: expected proportion of a response from the population in relation to the phenomenon studied;

y: margin of sampling error.

2.5. Choice of Participants

Inclusion criteria

Included in this study are students:

1) enrolled in a UFR of the Gaston Berger University of Saint Louis;
2) benefiting from CROUS services;
3) residing at the social campus for at least 3 months;
4) voluntarily agreeing to participate in the study;

Non-inclusion criteria

Not included in this study are students:

1) breastfeeding;
2) Pregnant;
3) refusing to participate in the study.

2.6. Samples and Biological Analysis Procedures

Venous blood was taken from each student and collected in two tubes (EDTA and dry tube) in order to explore the following parameters:

1) *Haematological parameters:* NFS (full blood count) using the multiparametric Coulter XN 350 (Sysmex) according to the following principle:

The counting system integrates flow fluor-cytometry and hydrodynamic focusing technologies to determine the various haematological parameters as well as the cyanide-free SLS (Sodium Lauryl Sulphate) method for measuring haemoglobin.

2) *Biochemical parameters:* thanks to the Mini-Vidas immunoanalytical machine (Biometious) and the CYAN Smart spectrophotometer (Cypress Diagnostics)

a) Ferritinemia:

Principle

The principle of the bioassay combines the one-step sandwich enzyme immunoassay with final fluorescence detection (ELFA).

During the final stage of revelation; the enzyme of the conjugate catalyzes the hydrolysis reaction of the substrate (4-Methyl-umbelliferyl phosphate) into a product (4-Methyl-umbelliferone) whose emitted fluorescence is measured at 450 nm. The value of the fluorescence signal is proportional to the concentration of the antigen present in the sample. »

b) Sideremia:

Principle: Colorimetric with differential method

Iron dissociates from the serum iron-transferrin complex in

weak acidic conditions. Free iron is reduced to a ferrous ion on contact with ascorbic acid. Ferrous ions in the presence of ferrozine form a coloured complex; the colour intensity is proportional to the concentration of iron in the sample.

c) C-reactive protein (CRP):

Principle

A suspension of latex particles coated with specific anti-human C-reactive protein antibodies is added to a test sample. The presence or absence of visible agglutination indicates the presence or absence of CRP in the samples tested.

2.7. Collection of Data

A questionnaire is administered to collect epidemiological, health and dietary data including weight, height, sex and age. Regular breakfast intake, consumption of meat, eggs, fish, poultry, as well as the frequency of tea consumption are included to assess participants' eating habits.

The body mass index of each individual is calculated by the ratio of weight in kilograms (kg) to the square of height in meters (m). Body weight and height are measured by a portable scale and tape measure respectively.

Biological data are collected following the analysis of blood samples. Anaemia was defined according to the thresholds recommended by WHO [7]:

1) Haemoglobin Hb level < 13g/dl in men.
2) Haemoglobin Hb level < 12g/dl in non-pregnant women.

Any participant with a haemoglobin level below the selected thresholds benefited from other complementary tests such as the determination of serum ferritin and iron to confirm or rule out iron deficiency anaemia.

2.8. Data Analysis

Data entry and statistical analysis are performed using Excel and Stata software.

The STUDENT t-test is used for the comparison of the means of the quantitative variables and the chi-square test for the qualitative variables. The significance level for the statistical tests was set at $p < 0.05$.

2.9. Ethical Considerations

This study is approved by the National Ethics Committee for Health Research (CNERS) of Senegal and is conducted in accordance with pre-established rules (Ref.: CER/UCAD/AD/MsN/011/2020).

3. Results

3.1. Socio-Demographic Variables

Of the 378 volunteers in the study, the average age was 23 with extremes ranging from 17 to 34. A female predominance was noted with a percentage of 56%. The M/F sex ratio was 0.8 (168 men and 210 women). The majority of the students came from the first cycle, including 270 from the Bachelor's level, 94 from the Master's level and 14 from the 3rd cycle (doctorate). Students from the UFR arts and humanities were more represented in this study as shown in Figure 1.

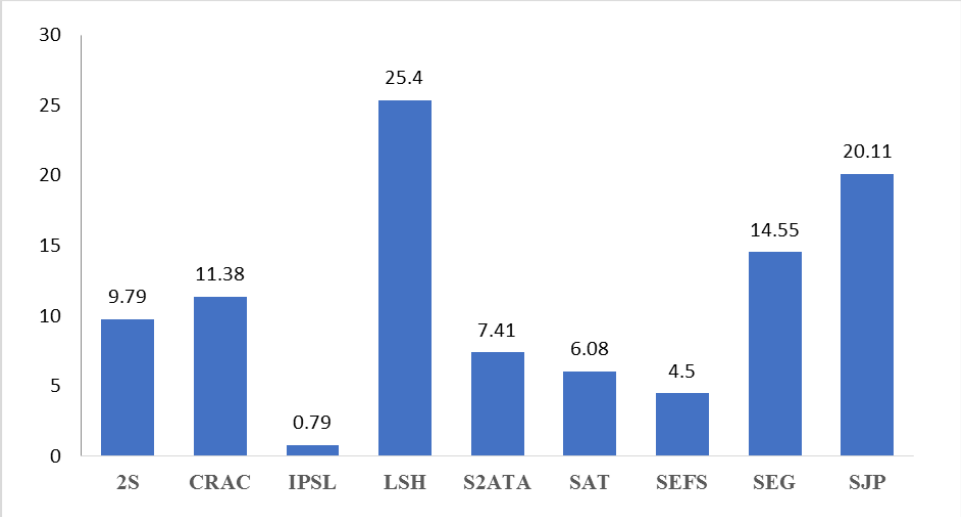

Figure 1. *Distribution of students by UFR of origin.*

3.2. Health Variables

The average body mass index (BMI) was 20.3 kg/m². More than half of the students (64.8%) were normal weight, 28% (105) were underweight, 6.08% (23) were overweight, and 1.32% (5) were obese. Regarding knowledge of anaemia, the majority of students did not know what anaemia was as shown in Table 1.

Table 1. *Level of knowledge of anaemia.*

Level of awareness	men (%)	women (%)
Bad	93 (55,4%)	134 (63,8%)
Good	75 (44,6%)	76 (36,2%)

With regard to dietary habits, the results of the survey showed that animal proteins are very present in the diet of students. They are eaten at least twice a day. Each student

consumed an average of 4 servings of meat; 2 servings of poultry and eggs and 3 servings of fish per week. Fruits and vegetables are little consumed by students. The average fruit consumption per student was 2 servings per week. Compared to milk, we noted that 94.18% consumed at least one dairy product once a day. The analysis of eating habits revealed that 113 students each drank an average of one cup of tea per day. Of these, 64.6% took it less than an hour after meals, 25.66% took it just before or after meals, while 9.73% took it simultaneously with their meals. For tobacco, unlike the men, none of the girls in our sample were declared smokers. However, 3 men declared to be smokers. The survey results also revealed that only girls consumed products such as kaolin and charcoal. The characteristics and lifestyle of the students have been summarized in Table 2:

Table 2. *Characteristics and lifestyle of the study population.*

Variables		Men (168)	Women (210)
marital status	Married	2 (1,2%)	6 (2,9%)
	Single	166 (98,8%)	204 (97,1%)
Old anaemia	Yes	8 (4,8%)	78 (37,1%)
	Not	160 (95,2%)	132 (62,9%)
Anaemia treatment	Yes	0 (0%)	21 (10%)
	Not	168 (100%)	189 (90%)
Vitamin or mineral supplement	Yes	14 (8,3%)	59 (28,1%)
	Not	154 (91,7%)	151 (71,9%)
Deworming	Yes	14 (8,3%)	39 (18,6%)
	Not	154 (91,7%)	171 (81,4%)
History of sickle cell disease	Yes	7 (4,2%)	26 (12,4%)
	Not	38 (22,6%)	73 (34,7%)
	Unspecified	123 (73,2%)	111 (52,9%)
Regular blood donation	Yes	6 (3,6%)	6 (2,9%)
	Not	162 (96,4%)	204 (97,1%)
Usual duration (day) of menses (208 responses)	less than / equal to 7 days	--	190 (91,3%)
	more than 7 days	--	18 (8,7%)
Contraceptive (208 responses)	Oral	--	1
	intrauterine device	--	1
	Implant contraceptive	--	2

3.3. Biological Variables

Tables 3 and 4 summarize the extreme and average values of haematological and biochemical parameters in the study population according to gender.

Table 3. *Haematological and biochemical parameters of the male population.*

Men	Number of observations	Average	Min	Max	Interval type
GR (10^6/µL)	168	5,32	2,86	7,70	0,30
Hb (g/dl)	168	14,60	4,20	18,54	0,72
HCT (%)	168	44,77	16,60	54,51	1,90
VGM (fl)	168	83,71	58,00	97,28	2,66
TCMH (pg)	168	27,16	14,70	38,28	1,21
CCMH (g/dl)	168	32,28	25,30	42,64	0,71
PLQ (10^3/µL)	168	318,69	83,00	571,00	32,22
GB (10^3/µL)	168	4,95	2,42	8,75	0,33
Fer ser (mg/l)	13	0,75	0,34	1,80	0,12
Ferritin (ug/ml)	13	20,42	1,50	54,84	5,83

Table 4. *Haematological and biochemical parameters of the female population.*

Women	Number of observations	Average	Min	Max	Interval type
GR (10^6/µL)	210	4,59	3,20	6,70	0,05
HB (g/dl)	210	12,09	6,70	15,43	0,12
HCT (%)	210	37,93	25,30	48,19	0,29
VGM (fl)	210	82,92	56,80	117,81	0,87
TCMH (pg)	210	26,31	13,40	36,10	0,36
CCMH (g/dl)	210	31,69	23,00	41,79	0,23
PLQ (10^3/µL)	210	379,40	167,40	730,60	10,84
GB (10^3/µL)	210	5,28	2,91	9,42	0,13
Fer ser (m/gl)	79	0,82	0,10	2,70	0,05
Ferritin (ug/ml)	79	19,82	1,50	157,54	2,74

The results showed that 12 students (3.2%) have a positive CRP and among them, 6 or 50% have a haemoglobin level

below the usual values.

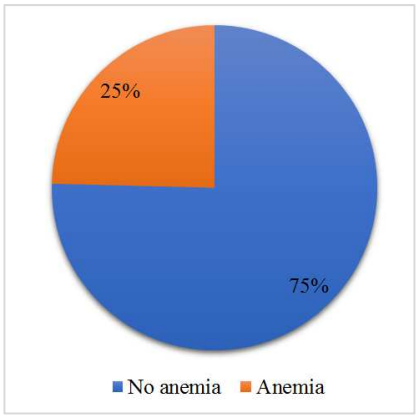

Figure 2. *Prevalence of anaemia in the study population.*

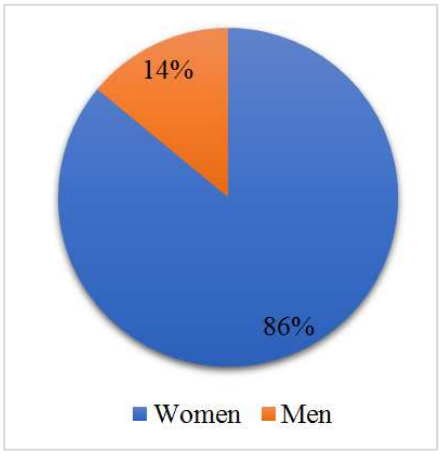

Figure 3. *Distribution of iron deficiency anaemia according to gender.*

3.4. Prevalence of Anaemia

Analysis of the data collected showed that out of a total number of 378 students, 93 had anaemia, i.e., a prevalence rate of 24.6% as shown in Figure 2. With respect to the severity of the anaemia, 64 (68.8%) had severe anaemia, 25 (26.9%) moderate anaemia and 4 (4.3%) severe anaemia. The prevalence of anaemia was higher in girls (86%) compared to boys (14%) as shown in Figure 3.

3.5. Type of Anaemia

Regarding the type of anaemia, the majority of anaemias were linked to iron deficiency as shown in Figure 4. This iron deficiency anaemia was found more in girls (68) than in boys (11).

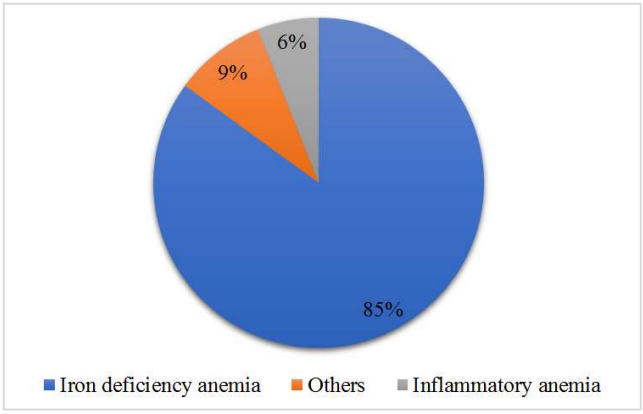

Figure 4. *Type of anaemia in the study population.*

3.6. Anaemia and Associated Factors

Table 5 shows the relationship between iron deficiency anaemia with age, BMI, marital status and education level. The results indicate that anaemia is more frequent in the age group <20-25> and less frequent in overweight or obese students. They also show that the level of study is inversely proportional to iron deficiency anaemia.

Table 5. *Relationship iron deficiency anaemia, age, BMI, marital status and level of education.*

Parameters	Non-anaemics students (n=299)	Anaemics students (n=79)	Valeur p
Age			
< 20	17 (5,7%)	4 (5,06%)	0,049
< 20-25 >	197 (65,9%)	62 (78,5%)	
> 25	85 (28,4%)	13 (16,5%)	
IMC			
< 18,5	81 (27,1%)	23 (29,1%)	
< 18,5-24,9 >	190 (63,5%)	54 (68,3%)	0,247
< 25-30 >	21 (7%)	2 (2,5%)	
> 30	7 (2,3%)	0	
Marital status			
maried	8 (2,7%)	0	0,302
single	291 (97,3%)	79	
Level of study			
first cycle	206 (69%)	63 (79,7%)	0,223
second cycle	79 (26,4%)	15 (19%)	
third cycle	14 (4,6%)	1 (1,3%)	

Analysis of student diet data showed that the prevalence of anaemia was higher among those who did not consume foods high in iron. Table 6 summarizes this relationship.

Table 6. *Distribution of anaemic and non-anaemic students: anaemia according to dietary habits.*

Variables	Responses	Non-anaemics students (n=299)	Anaemics students (n=79)	Valeur de Khi 2	Valeur P
Meat	Rare	54 (18,6%)	63 (79,7%)	0,2590	0,611
	Frequent	245 (81,9%)	16 (20,3%)		
Poultry	Rare	242 (80,9%)	68 (86,1%)	1,0064	0,316
	Frequent	57 (19,1%)	11 (13,9%)		
Egg	Rare	151 (50,5%)	42 (53,2%)	0,0892	0,765
	Frequent	148 (49,5%)	37 (46,8%)		
Milk and dairy milk	Rare	125 (41,8%)	42 (53,2%)	2,8014	0,094
	Frequent	174 (58,2%)	37 (46,8%)		
Legumes	Rare	204 (68,2%)	59 (74,7%)	1,0618	0,303
	Frequent	95 (31,8%)	20 (25,3%)		

4. Discussion

Iron deficiency anaemia is the most common type of anaemia and is the most common and widespread nutritional disorder in the world. While it affects a large number of children and women in developing countries, it is also the only nutrient deficiency with a high prevalence in industrialized countries [8]. Numerous studies have shown the association of iron deficiency anaemia with impaired cognitive performance and work productivity in adults [9-11].

The majority of previous studies granted in the country were for children and women of childbearing age. Very few studies have been adapted to assess the extent of this problem in universities composed mainly of a young population whose quality of food is often decried. Studies have shown that iron deficiency and iron deficiency anaemia can cause permanent psychomotor disorders, as well as disrupt cognitive, intellectual, socio-emotional functions and the sleep-wake cycle. This study was conducted to determine the frequency of iron deficiency anaemia among students at the Gaston Berger University of Saint Louis in Senegal.

Our study population consisted of 378 volunteers whose average age is 23 years with extremes ranging from 17 to 34 years. There was also a female predominance with a sex ratio M/F of 0.8. This imbalance is only a reflection of the general population with a clear female predominance but also by the high interest of women in these screening campaigns. The average age of 23 years is also a reflection of the national population in which more than 50% of the population is under 20 years old [12]. Despite their level of education, the majority of students are unaware of the definition and signs of anaemia, hence the importance of raising awareness in order to ensure early detection and follow-up. Although proteins are present in the diet of the students, a large majority consumed tea immediately after meals, which can interfere with the bioavailability of iron and lead to long-term deficiency anaemia.

In our study, the prevalence of anaemia recorded (24.6%) implies that it constitutes a public health problem in this student population. Similar results have been found in other universities. Thus, among medical students at Hodeida University (Yemen), the prevalence of iron deficiency anaemia was found to be 30.4%, of which 54.00% were women and 46.0% men. [13]. Furthermore, the prevalence of iron deficiency was 40.9% and that of iron deficiency anaemia was 3.8% among Iranian university students [14]. The prevalence rate of anaemia was also found to be 55.3% among students in Noakhali, Bangladesh [15].

More than half (68.8%) of the cases had mild anaemia. This high prevalence was close to that found in other African cities, particularly in Morocco [16], Algeria [17], Cape Verde [3]. The majority of these anaemias are linked to iron deficiency (iron deficiency) in 85% of cases. This confirms literature data that iron deficiency is the most common form of micronutrient deficiency [4]. It is also higher in girls (80 cases) than in boys (13 cases). Women, especially of childbearing age, are more prone to anaemia than men due to menstruation. Indeed, according to various studies, the majority of women have menstrual iron losses of between 12.5 and 15 mg, which corresponds to 0.4 to 0.8 mg/day, which can lead to anaemia [18]. Another cause described relates to insufficient intake of dietary iron, low bioavailability and concomitant insufficient intake of dietary micronutrients [19].

Dietary analysis showed that the prevalence was higher in students who did not consume enough foods high in heme iron (meats and dairy products). However, the difference was not statistically significant ($p<0.094$) probably related to the weakness of the sampling and its cross-sectional nature. On the other hand, 17 out of the 79 students with iron deficiency anaemia consumed tea regularly and preferably after meals. A study carried out in Morocco confirmed that excessive tea consumption was a risk factor [20]. Tea contains theophylline which acts as an iron chelator and this may decrease the absorption and bioavailability of iron. Thus, we suggest the implementation of an awareness and information program on the prevention of anaemia including systematic screening for anaemia and recalling the importance of a healthy, balanced and diversified diet. This is all the more urgent since it has been found that the prevalence of anaemia was also higher among students who ate meals outside the social campus (fast food, eateries, shops etc... or most of the food consisted of cereals.

A limit to this study is related to the lack of a follow-up program for these students. This is why we suggest that it would be relevant to conduct more in-depth and longitudinal studies in this direction as well as a curative supplementation program in order to reduce these deficiency anaemias in universities.

5. Conclusion

In Senegal, despite the numerous means deployed by the state to improve the living conditions of students, deficiencies in micronutrients, particularly iron, remain a public health problem. Due to the impact of anaemia on physical growth, cognitive development, reproduction and physical work capacity, awareness and screening strategies should be encouraged to ensure early detection and implementation a curative supplementation program to reduce these deficiency anaemias in universities.

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