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Can urbanization affect the occurrence of anemia in children 6 to 59 months of age in malaria endemic settings? A cross-sectional survey in Burkina Faso

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Anemia in children remains a major public health concern in low- and middle-income countries. This study aimed to assess the prevalence and effect of urbanization on the occurrence of anemia in an endemic malaria urban area in Burkina Faso. A cross-sectional community-based study was carried out in both old and recent areas of Bobo-Dioulasso, Burkina Faso, and included 875 children aged 6 to 59 months. For all participants, socio-economic, demographic, and anthropometric data, as well as information on diets and residences, were collected. Additionally, blood samples were drawn for hemoglobin assessments and malaria detection. Multiple linear regression was used to test the association between hemoglobin concentration and participants' residences. In this study, 52.11% of participants were male, and the mean (±SD) age was 32.0 (±0.5) months. The mean (±SD) hemoglobin concentration was 10.37 (±1.57) g/L. The majority (61.3%) of children had anemia, with a significant difference between old and recent areas (p=0.003). The prevalence of anemia in the old and recent areas was 66.0% and 56.4%, respectively. However, a strong positive modifying effect from old to recent areas (p=0.002) was found regarding hemoglobin concentration. This study showed that living in either an old or recent area in endemic malaria urban Burkina Faso affects hemoglobin concentration. Interventions to reduce childhood anemia must include considerations of residency patterns.

Key words: Burkina – Faso, anemia, children, urban, old area, recent area.

INTRODUCTION

Anemia is defined as a blood hemoglobin concentration ≤ 11g/L in children (Diouf et al., 2015). It is one of the most serious public health problems affecting people in both developing and industrialized countries (Kweku et al., 2017). It is known to have significant health consequences, social impacts on economic development, and effects on physical growth, and is considered one of the indicators of poor individual nutrition (Crawley, 2004; WHO, 2015). The global prevalence of anemia was estimated at 42.6%, affecting more people in low- and middle-income countries, including regions such as South-East Asia, Eastern Mediterranean, and Africa (Diouf et al., 2015; WHO, 2015). Children under 5 years old and pregnant women bear the heaviest burden.

Several factors contribute to iron deficiency and anemia, such as younger maternal age, lack of participation, and the non-consumption of iron-rich food sources (such as, meat, beans, dark green leafy vegetables) (Zuffo et al., 2016). Infectious diseases, particularly malaria and helminth infections, are also significant contributors to the high prevalence of anemia in many populations (Ouédraogo et al., 2008).

In poor settings, infections such as malaria and intestinal parasites are leading causes of anemia (Sanou et al., 2008). Anemia remains one of the most difficult public health concerns to manage in malaria-endemic countries (Crawley, 2004).

In Burkina Faso, where infections like malaria and diarrhea are persistent, anemia is a major public health concern. It was estimated that 92% of children aged 6-59 months are affected by anemia, with almost all children (93.6%) in rural areas being affected (INSD and ICF, 2004; Sanou et al., 2008). Anemia was the second leading cause of hospitalization (6.0%) and the fifth leading cause of death (3.6%) among children under 1 year old (INSD and ICF, 2004). The primary causes of anemia include diet-based iron deficiency, malaria, intestinal diseases, and sickle cell disease (Inocent et al., 2009). To address these issues, various interventions have been implemented, such as iron supplementation during pregnancy, food fortification, promoting dietary diversity, deworming, and the distribution of insecticide-treated bed nets (DN, 2015).

Despite these efforts, the prevalence of anemia in children remains high in Burkina Faso.

Studies conducted in rural areas have identified several predictors of anemia, including poor household conditions (Sanou et al., 2008). Significant differences between rural and urban areas in low- and middle-income countries have been noted (Pasricha et al., 2010). However, evidence on the prevalence of anemia within the same city, particularly in relation to urbanization (defined as the gradual development from old to new neighborhoods), remains unclear.

In a context where cities are continuously developing, the current study was carried out to assess the impact of urbanization on the occurrence of anemia in children aged 6-59 months in an endemic urban setting in Burkina Faso. This study aimed to provide evidence on whether urbanization can be considered a contributing factor to anemia in an endemic malaria urban setting in Burkina Faso among children under 59 months old.

MATERIALS AND METHODS

Study area

The study was carried out in Bobo-Dioulasso, the second-largest city and economic capital of Burkina Faso. Located in the southwestern part of the country, Bobo-Dioulasso covers an area of 13,678 hectares and has a population of about one million, mostly young and female (Werthmann and Sanogo, 2013). Since 2013, the city has been restructured into 33 urban sectors divided into seven "arrondissements," which include 36 villages (Zida-Bangré, 2009). The tertiary sector dominates the city, employing 77.1% of the active population (Zida-Bangré, 2009). The city's industrial activities span agri-food, chemicals, and their derivatives (Werthmann and Sanogo, 2013).

The climate in Bobo-Dioulasso is South Sudanese, characterized by a long dry season from October to April and a rainy season lasting five months from May to September. Over the past ten years, annual rainfall has varied between 900 and 1250 mm, allowing the local population to engage in agriculture. Despite the numerous and diverse healthcare facilities in urban areas, access remains limited for the entire population. This, combined with general illiteracy and low income, contributes to various types of malnutrition in the city. Infections related to malnutrition (parasitic, bacterial, and viral) are prevalent in this area. Malaria, diarrhea, and acute respiratory infections are the leading causes of consultations for children under five years old (Dafra, 2021).

The current study focused on four areas: Dogona, Yéguéré, Secteur 25, and Tounouma. Tounouma and Dogona are classified as old urbanized areas, while Secteur 25 and Yéguéré are considered recent ones. A river runs through the old areas. The characteristic differences between these sub-study areas were previously described (Kassie, 2015), and the main differences are summarized in Table 1.

Study population and period

This report is a secondary analysis of data from the project named SANTé, INégalités villES (SANTINELLES), an acronym for “Health, disparities and Urban cities” (Kassie, 2015). Study was carried out from October 2013 to October 2015 and included 881 children, both sexes, 6 – 59 months of age, who have not planned to leave study area during the study period and whose parents have signed a written, inform consent form. Participants with complete data were considered in this analysis (n=875).

Participant selection and variables

As part of a project, this section has been described in a previous published article (Zeba et al., 2017). Briefly. after inclusion, each participant’s mother or caregiver was interviewed by a trained nurse to collect information on socio-demographic, occurrence of fever within the past 14 days, diet, etc. At the end of the interview, anthropometric, clinical data and blood samples were collected.

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Table 1. The characteristic differences between the recent area and old areas of the study.

Parameter	Old area	Recent area
Proximity to the Center of the city	++++	-
Proximity to the hospital public	+++	+
Proximity to the river	+++	-
Presence of school	++++	+
Presence of sanitation	+++++	+
Population density	+++	+

The + shows that the sub area is closed to the center of the city and the infrastructures were present; however, the – shows the sub area is far from the center of the city and the river.

Blood samples were used to test malaria presence and hemoglobin concentration.

Laboratory evaluation of malaria

Diagnosis of malaria

Malaria status was performed as previously described and using diagnosis rapid test for malaria and malaria smear(Sombie et al., 2020). Malaria RDT, SD Bioline Ag Pf / Pan (Standard Diagnosis, Korea) was used. The test was performed according to the manufacturer instructions by trained nurses as follow. Briefly, 5 µl of blood drop are collected and deposited in the round hole (hole "S" of test cassette). Four drops of the buffer are added carefully in the square hole of the test cassette. The appearance of the band C only means the test is negative. When both the control band C and Pf line or the band C and the Pan line are visible, the test is positive.

At the same time, a thick blood smear was also performed by the trained nurses who carried out the RDT test. The thick blood smear was dried immediately and then transported to the laboratory for processing and microscopy. At the laboratory, the slides were dried, stained with Giemsa 10% in water (V/V) and read by two experienced microscopists. In case of discrepancy of the two results, a third reading was done. The test is positive when parasite « plasmodium was found (Iqbal et al., 2016; Sombie et al., 2020).

Hemoglobin assessment

For each participant, a drop of blood was taken from the finger for hemoglobin concentration. A point-of-care HemoCue instruments (Hb-301, Ängelholm, Sweden) was used for hemoglobin concentration assessment. The cut off used to define anemia is described as following: hemoglobin concentration <11 g/dL for children between 6–50 months of age, and < 11.5 g/dL in children more than 5 years old. Anemia is classed as mild at hemoglobin concentration above 10 g/dL, moderate between 7 and 9.9 g/dL, and severe below 7 g/dL (Lemoine and Tounian, 2020)

Anthropometric data

Anthropometry data collection was described in a previous paper (Zeba et al., 2017). For accurate body weight measurements, each participant was weighed in light clothing and without shoes using a portable electronic scale (Seca 803 Clara Scale; capacity 150 kg; graduation 100 g). Height was measured to the nearest 0.5 cm using a portable, locally built stadiometer with the subject standing upright on a flat surface without shoes and the back of the heels, and the occiput against the stadiometer.

Mid-upper arm circumference (MUAC) was measured with a flexible steel tape (Gulick© measuring tape) to the nearest 0.1cm at the midpoint of the arm. Body weight, height, and MUAC were measured twice, and the mid-point of the two values was used for the analysis.

Clinical assessment

During the baseline data collection, children were examined by a certified physician for clinical signs of anemia such as conjunctival, palms and soles pallor, and small and spinning pulse. In addition, axillary body temperature was taken. The presence of edema was checked.

Food intake assessment

A 3 days nonconsecutive 24-hour recall has been conducted according to the method described by World Health Organization (WHO, 2010) and used to estimate participants' food intake. Seven food groups were used and included (1) grains, roots, and tubers (cereals, roots, and tubers), (2) legumes and nuts, (3) dairy products (milk, yogurt, cheese), (4) flesh foods (meat, fish, poultry and liver/organ meats), (5) Eggs, (6) vitamin A rich fruits and vegetables, (7) other fruits and vegetables.

Data management, process, and statistical analysis

Data management

EpiData version 3.1 (EpiData Association, Odense, Denmark) was used for all data entry. Data entry was done twice. The Data quality control was continuously performed through automatic consistency checks. Queries were sent to the investigators for correction. At the end of data cleaning, data set was transferred to Stata software, version 15.1 (Stata Corp, TX, USA) for analysis.

Data process

From the anthropometric measurement and using the WHO Anthro 2006 package on Stata, weight, and height were converted into Z-score - weight - for – age (WAZ), Z – score - weight - for – height

(WHZ), Z - score - height – for – age (HAZ). The cut of hemoglobin concentration (hb) <11 g/dL was considered as anemia. Severe and moderate anemias were respectively defined at the cut of hb <7.0g/dL and hb <9g/dL. The consumed food groups were summed to estimate the food diversity score (FDS). Multiple Correspondence analyses was performed to build a proxy of the income level using data on household assets, such as television, digital video disc (DVD), fridge, motorbike, or car, house ownership, type of household toilet, electricity, type of cooking fuel, type of floor, roof, and walls.

Statistical analysis

Statistical analysis was conducted using STATA (version 15.1, StataCorp TX, USA). Quantitative and normally distributed data were expressed as mean ± standard deviation (SD), and the non-normally distributed data, median, and quartiles 25 and 75 were used. For categorical variables, percentages with 95% confidence intervals (CI) were used. To compare the means of normally distributed variables between groups, the “t-Test” and the analysis of variance (ANOVA) were used for two or more than two groups, respectively. For this latter, Bonferroni post hoc test was performed in case the overall test was statistically significant. For the proportion comparison of categorical variables, the χ^2 test was used. A multiple linear regression was performed to assess the association between hemoglobin and the potential factors. In the first step, the dependent variable (hemoglobin concentration) was tested with the independent variable (residence). In the second step, an adjusted model for participant sex, age, mother education, food diversity score (FDS), household index, and nutritional status was performed. Esta test was used for the validity of the models. Statistical significance was set at 5% for all analysis.

Ethical consideration

The study protocol was examined and approved by the ethical committees of the “Centre Muraz” and of the “Institut de Recherche en Sciences de la Santé” under the number: A30-2013. It was carried out according to the Declaration of Helsinki guidelines. During the screening process, the study aims and procedures were explained to each participant’s caregiver, each householder, the local authorities, and the community. A written informed consent was obtained from each participant’s caregiver before child’s inclusion. Participants with abnormal results were referred to a specialist for diagnosis and treatment, the cost of which was supported by the research project. Data collected from participants were confidential.

RESULTS

Socio-demographic characteristics of study participants

A total of 881 children were enrolled in this study, and 875 have complete data. Study participants' mean (±SD) age was 32.0 (±0.5) months. Boys represented 52.1% of participants. Almost the same number of participants was living in both old and recent areas (50.96 vs. 49.04%). The illiterate participants were 41.3%. Table 2 summarizes the main characteristics of the study participants.

Prevalence of anemia

The hemoglobin's mean (±SD) concentration was 10.38 (± 1.56). It was 10.18 (±1.47) for old area and 10.57 (±1.64) for the recent one. A significant difference was found between the two areas. The majority (61.29%) of study participants was found to have anemia. The proportions of mild, moderate, and severe anemia were 25.4, 33.8 and 3.1%, respectively. The main components of the anemia per study area are shown in Table 3.

Anemia and area status

In a univariate analysis, a significant positive association was found between residents and the concentration of hemoglobin (β= 0.386, p < 0001). An adjusted model for the participant’s sex, age, malaria status, mother’s education, food diversity score (FDS), household socio-economic index, the association between predictors, and hemoglobin concentration ranged from -1.667 to 0.362. In addition, strong positive significant associations were found with malaria status (β =-0.584p=0.002), participant age (β = 0.037p< 0.0001), mother secondary school education (β =0.237, p=0.04), rich household index (β=0.378, p=0.002), and a resident pattern was found (β=0.316p=0.002). Table 4 summarizes the adjusted analysis.

DISCUSSION

This study compared the differences between hemoglobin concentrations and socio-demographic factors in participants living in the city of Bobo-Dioulasso. Hemoglobin concentrations determine types of anemia. High prevalence of anemia was found in this urban setting where infections such as malaria, diarrhea and low food diversity score were frequent. Moderate anemia was the most common. Assessing the disparity of anemia in the same city was not common. The findings were in line with the high prevalence of anemia previously observed in children in West Africa (Shenton et al., 2020). In Burkina Faso, either community(Sanou et al., 2008; INSD and ICF, 2021) or hospital studies (Sawadogo et al., 2020) found high prevalence of anemia. As explained previously, the high prevalence of anemia suggests that children living in Burkina have globally a low FDS with low vegetable intake and inadequate iron intake (Sanou et al., 2008). Additionally, it has also been demonstrated, in burkinabè children, that intestinal (hookworm, and other helminths) and sickle cells diseases such as thalassemia, contributed to increasing anemia prevalence (INSD and ICF, 2021). This assumption can also be considered even if the present research was not focused on these diseases. Incomplete laboratory investigations have limited the

Table 2. Socio-demographic characteristics of participating children by area.

Parameter		Overall	Old area (n=448)	Recent area (n=427)	P value
Age: mean (SD[1])		32.0 (0.49)	31.3 (14.8)	32.7 (14.14)	0.11
Sex n (%)	F	419 (47.9)	221 (49.3)	198 (46.4)	0.76
	M	456 (52.1)	227 (50.7)	229 (53.6)	
Fever within 14 days n (%)	Yes	241 (27.8)	124 (28.1)	117 (27.5)	0.05
	No	626 (72.2)	317 (71.9)	309 (72.5)	
Fever at admission n (%)	Yes	260 (30.0)	138 (31.3)	122 (28.6)	0.72
	No	607 (70.0)	303 (68.7)	304 (71.4)	
Diarrhea at the admission n (%)	Yes	47 (5.4)	24 (5.4)	23 (5.4)	0.98
Malaria status n (%)	Positive smear	168 (19.1)	98 (21.8)	70 (16.2)	0.03
	Positive RDT	159 (18.3)	95 (21.5)	64 (15.0)	0.00
Nutritional status	WAZ: mean (SD[1])	-0.73 (0.03)	-0.76 (1.14)	-0.71 (1.140)	0.39
	HAZ: mean (SD[1])	-0.83 (0.04)	-0.81 (1.35)	-0.84 (1.34)	0.73
	WHZ: mean (SD[1])	-.40 (0.04)	-0.44 (1.15)	-0.36 (1.21)	0.20
	Severe underweight n (%)	26 (3.0)	13 (3.0)	13 (3.0)	0.35
	Severe wasting n (%)	15 (1.7)	15 (1.7)	10 (2.4)	0.25
	Severe stunting n (%)	45 (5.2)	26 (5.9)	19 (4.5)	0.80
Mother's education n (%)	None	365 (41.3)	180 (40.0)	185 (42.7)	0.37
	Primary school	141 (16.0)	69 (15.3)	72 (16.6)	
	Secondary school	277 (31.4)	151 (33.6)	126 (29.1)	
	University	37 (4.2)	14 (3.1)	23 (5.3)	
	Local education	30 (3.4)	17 (3.8)	13 (3.0)	
	Other	33 (3.7)	19 (4.4)	14 (3.2)	
FDS[2]	Food groups (SD[1])	2.4 (1.4)	2.6(1.4)	2.3(1.5)	0.001
Household socio-economic index	Poor	251 (28.6)	113 (25.4)	138 (31.9)	0.075
	Moderate	214 (24.4)	109 (24.5)	105 (24.3)	
	Rich	412 (47.0)	223 (50.1)	189 (43.8)	

[1]Standard deviation; [2] Mean food diversity score.

Table 3. Study participant's hemoglobin status.

Parameter	Overall	Old area	Recent area	P value [2]
Hemoglobin concentration mean (SD)	10.38 (1.56)	10.18 (1.47)	10.57 (1.64)	0.0006
Anemia[1]	540 (61.3)	297 (66.0)	243 (56.4)	0.005
Mild[1]	220 (25.4)	116 (26.3)	104 (24.4)	
Moderate[1]	293 (33.8)	165 (37.4)	128 (30.1)	
Severe[1]	27 (3.1)	16 (3.6)	11 (2.6)	

[1]variable expressed in number of participants and percentage; [2]ANOVA was used.

ability to distinguish these diseases such as hemolysis, dyserythropoiesis, and other diseases leading to anemia.

Table 4. Association between hemoglobin concentration and sociodemographic factors.

Parameter		Hemoglobin concentration	
		β	P value
Age		0.0369	<0001
Sex	Female vs. male (ref[3])	-0.1838	0.09
WHZ[1]		0.0019	0.90
FDS[2]		-0.0251	0.51
Mother formal education	None (ref[3])	0	
	Primary school	0.1003	0.49
	Secondary school	0.2371	0.04
	University	0.4371	0.09
	Local education	-0.0621	0.82
	Other	0.3352	0.21
	Poor (ref[3])	0	
Household socioeconomic index	Moderate	-0.0289	0.83
	Rich	0.3782	0.002
Malaria status[4]	Positive vs. negative (ref[3])	-0.5839	0.002
Residence area	Recent vs. old (ref[3])	0.3156	0.002

[1]weight – for - height Z score; [2] food diversity score; [3] reference; [4]malaria smear was used in the model.

Anemia prevalence was significantly higher in old area than in recent one, suggesting that urbanization process demographic and health surveys (Kothari et al., 2019). In old area, hygiene, sanitation and potable water supplies plays an important role in the occurrence of anemia. The main reason for the differences between recent and old areas is likely to be water, sanitation and hygiene issues as found in Kothari's study in 47 nationally representative are poor. Additionally, the high density of the population leads to the development of the higher rates of infections and parasitic diseases as described in Netherlands study (Levy and Herzog, 1974) and can also be expected regarding these conditions. In this study, no difference of diarrhea prevalence was found between the two areas. However, malaria was more prevalent in the old area than in the recent area. The high prevalence of malaria in old setting could explain the difference in anemia. Several previous studies have shown an association between anemia and symptomatic malaria (Hedberg et al., 1993). A significant association between malaria and anemia suggesting that the presence of malaria decrease hemoglobin concentration. Since most of the children in this study were asymptomatic, it could be suggested that asymptomatic malaria is also a strong risk factor for anemia in children. The mechanism responsible for malaria-related anemia involves predominantly acute hemolysis compared to dyserythropoiesis or ineffective erythropoiesis due to recurrent parasitemia (Greenwood, 1987). However, other reasons for the differences between the recent area and the old one is likely to be: a) the high density of population in old area than in recent one, b) the sanitation matter which contributed to the development of the nid of mosquitoes and increased the prevalence of malaria. A positive and significant association was found between anemia and the old age of the participant. The same result was found by Zuffo and all in children 6 – 36 months of age in the metropolitan region of Curitiba in Brasilia (Zuffo et al., 2016). Infants also generally have a higher incidence of infectious diseases, which can reduce their ability to ingest and absorb iron, perhaps further explaining the higher prevalence of anemia among younger children (Villalpando et al., 2003).In the model, we controlled for a proxy for the socioeconomic asset, which could have attenuated any association between illness and anemia, as clean water, improved sanitation and lifestyle are associated with a lower risk of pathogen exposure, illness and inappropriate iron losses (infection, inflammation and infestation). This observation, as previously described, suggests that broader socioeconomic conditions directly influence hemoglobin levels in children (Pasricha et al., 2010).

Conclusion

This study found that living in an old area exposed people to a higher risk of anemia compared to living in a recent area.

Given these findings and the risk factors described in several recent papers, the implementation of urgent measures to tackle anemia should take into account the residence patterns within the same city, including both old and recent areas, for effective prevention and treatment.

However, a single intervention might not be successful if other measures are not taken simultaneously.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Crawley J (2004). Reducing the burden of anemia in infants and young children in malaria-endemic countries of Africa: from evidence to action. The Intolerable Burden of Malaria II: The American Journal of Tropical Medicine and Hygiene 71(2).

Dafra D (2021). Plan d'action du district sanitaire de Dafra. Mdl santé, ed. (Dbob Dioulasso) P 101.

Diouf S, Folquet M, Mbofung K, Ndiaye O, Brou K, Dupont C, N'dri D, Vuillerod M, Azais-Braesco V, Tetanye E (2015). Prevalence and determinants of anemia in young children in French-speaking Africa. Role of iron deficiency. Archives De Pediatrie: Organe Officiel De La Societe Francaise De Pediatrie 22(11):1188-1197.

DN (2015). Plan de renforcement de la lutte contre les carences en micronutriment 2015-2020. Bf Direction de la nutrition du ministère de la Santé, ed. (Ouagadougou, Burkina Faso) P 47.

Greenwood BM (1987). Asymptomatic malaria infections-do they matter? Parasitology Today 3:206-214.

Hedberg K, Shaffer N, Davachi F, Hightower A, Lyamba B, Paluku KM (1993). Plasmodium falciparum-associated anemia in children at a large urban hospital in Zaire. The American Journal of Tropical Medicine and Hygiene 48:365-371.

Inocent G, Bertrand PM, Honoré FK, Odette Z, Salomé N, Valéry C, Georges GE, Henri AZ (2009). Physiopathologic factors resulting in poor outcome in childhood severe malaria in Cameroon. The Pediatric Infectious Disease Journal 28(12):1081-1084.

INSD, ICF (2004). Enquête démographique et de santé et à indicateurs multiples (EDSBF-MICS IV), Rapport préliminaire, Burkina Faso, 2003. Indlsedl demographie, ed. (Ouagadougou, Burkina Faso) P 40.

INSD, ICF (2021). Enquête démographique et de santé et à indicateurs multiples (EDSBF-MICS IV), Rapport préliminaire, Burkina Faso, Ouagadougou: INSD P 73.

Iqbal SA, Botchway F, Badu K, Nana WO, Dei-Adomakoh Yvonne, Dickinson-Copeland CM (2016). Hematological differences among malaria patients in rural and Urban Ghana. Journal of Tropical Pediatrics 62:477-486.

Kassie D (2015). Segmentations urbaines et disparités de santé dans une ville moyenne africaine: du paludisme aux états nutritionnels à Bobo-Dioulasso (Burkina Faso). Université Paris Ouest Nanterre La Défense.

Kothari MT, Coile A, Huestis A, Pullum T, Garrett D, Engmann C (2019). Exploring associations between water, sanitation, and anemia through 47 nationally representative demographic and health surveys. Annals of the New York Academy of Sciences 1450(1):249-267.

Kweku M, Parbey PA, Takramah W, Owusu R, Axame WK, Adjuikk M (2017). Assessment of the prevalence of anaemia and associated risk factors among children under five years in rural communities ofthe hohoe municipality, Ghana. International Journal of Nursing Didactics 7(7):11-20.

Lemoine A, Tounian P (2020). Childhood anemia and iron deficiency in sub-Saharan Africa–risk factors and prevention: A review. Archives de Pédiatrie 27:490-496.

Levy L, Herzog AN (1974). Effects of population density and crowding on health and social adaptation in the Netherlands. Journal of Health and Social Behavior, pp. 228-240.

Ouédraogo HZ, Dramaix-Wilmet M, Zeba AN, Hennart P, Donnen P (2008). Effect of iron or multiple micronutrient supplements on the prevalence of anaemia among anaemic young children of a malaria-endemic area: a randomized double-blind trial. Tropical Medicine and International Health 13:1257-1266.

Pasricha S-R, Black J, Muthayya S, Shet A, Bhat V, Nagaraj S (2010). Determinants of anemia among young children in rural India. Pediatrics 126:e140-e149.

Sanou D, Turgeon-O'Brien H, Desrosiers T (2008). Prévalence et déterminants non alimentaires de l'anémie et de la carence en fer chez des orphelins et enfants vulnérables d'âge préscolaire du Burkina-Faso. Nutrition Clinique Et Métabolisme 22:10-19.

Sawadogo S, Nébié K, Millogo T, Kafando E (2020). Blood transfusion requirements among children with severe malarial anemia: a cross-sectional study in a second level reference hospital in Burkina Faso. The Pan African Medical Journal, p. 37.

Shenton LM, Jones AD, Wilson ML (2020). Factors Associated with Anemia Status Among Children Aged 6-59 months in Ghana, 2003-2014. Maternal and Child Health Journal 24:483-502.

Sombie OO, Abbeddou S, Kazienga A, Valea I, Moulin AM, Zeba A (2020). Assessment of the performance of malaria rapid diagnostic test in acutely malnourished children under five years of age in Nanoro-Burkina Faso. Journal of Parasitology and Vector Biology P 12.

Villalpando S, Shamah-Levy T, Ramírez-Silva CI, Mejía-Rodríguez F, Rivera JA (2003). Prevalence of anemia in children 1 to 12 years of age. Results from a nationwide probabilistic survey in Mexico. Salud publica de Mexico 45(4):490-498.

Werthmann K, Sanogo ML (2013). La ville de Bobo-Dioulasso au Burkina Faso: urbanité et appartenances en Afrique de l'Ouest. (KARTHALA Editions).

World Health Organization (WHO) (2010). Indicators for assessing infant and young child feeding practices: part 2: measurement.

World Health Organization (WHO) (2015). The global prevalence of anaemia. World Health Organization.

Zeba AN, Yaméogo MT, Tougouma SJB, Kassié D, Fournet F (2017). Can urbanization, social and spatial disparities help to understand the rise of cardiometabolic risk factors in bobo-dioulasso? A study in a secondary city of Burkina Faso, West Africa. International Journal of Environmental Research and Public Health 14:378.

Zida-Bangre H (2009). Monographie de la commune urbaine de Bobo Dioulasso. Institut National de la Statistique et de la Démographie (INSD), Ouagadougou, Burkina Faso.

Zuffo CRK, Osório MM, Taconeli CA, Schmidt ST, Silva BHCd and Almeida CCB (2016). Prevalence and risk factors of anemia in children. Jornal De Pediatria 92:353-360.