Anaemia in Children aged 6-59 Months in the Eastern and Northern Regions of Cameroon

WANGMENE DJONREBELE Pierre, BOUBA DJOURDEBBÉ Franklin, EKAMBI Emmanuel
Institut of Training and Demographic Research (IFORD)/University of Yaounde II (Cameroun)
DOI: https://dx.doi.org/10.47772/IJRISS.2023.701137
Received: 11 April 2023; Revised: 30 June 2023; Accepted: 05 July 2023; Published: 17 November 2023

ABSTRACT

Early childhood is a very critical period for the future growth and development of children whose care is fundamentally urgent. Thus, the elimination of nutrition-related diseases such as anaemia that is likely to delay the achievement of targets 3.2 and 4.2 of the SDGs fits-in at the right time in this logic. Cameroon, like the rest of developing countries, has a high prevalence rate of anaemia. The situation is alarming in the three Northern and Eastern regions of the country. The objective of this article is to make a comparison of the explanatory factors of anaemia in the three Northern and Eastern regions through a three-level logistic regression. It appears from the individual characteristics that the anaemic state of the mother, her level of education, the age of the child explain anaemia in the study regions, except the nutritional state and the duration of breastfeeding which explain it distinctly in the three Northern and Eastern regions respectively. With regard to household characteristics, one and only one characteristic determines anaemia in each region, namely the main activity of the household head in the three Northern regions and the household standard of living in the Eastern region. No community characteristic was found to explain anaemia in the three Northern regions, unlike in the Eastern region where the type of place of residence, the proportion of educated women and the level of immunization coverage in the community are determining factors. The contribution of the article is to shed light on the common and specific determinants of anaemia in children aged 6-59 months three Northern and Eastern regions of Cameroon.

INTRODUCTION

Child protection has long been a growing concern of all organizations and is part of the pursuit of an overall goal that transcends even the idea of protecting children from a risky environment, but must be able to " *guarantee all children a risk-free environment that cares about their well-being, favourable to their development and fulfillment in all contexts*" (Toussaint et al., 2019). In doing so, the eradication of child-related diseases aims to prepare them for a healthy life in adulthood (Pomarede et al., 2014), because early childhood is a very decisive period for children (Bouba Djourdebbé, 2015). Thus, the relentless fight against nutritional deficiencies and infections would be an undeniable contribution to the reduction of death and certain diseases in children, and in particular anaemia.

Indeed, anaemia is an indicator of poor nutrition and health (WHO and UNICEF, 2004). It is characterized by the fall below a low level in the number and size of red blood cells, or the decrease in hemoglobin, by affecting the ability of the blood to carry oxygen in the body (WHO, 2017). It has been recognized by some researchers that iron deficiency explains more than 50% of the prevalence of anaemia in the world (Tolentino and Friedman, 2007). However, anaemia can also occur following infections (malarial and parasitic) and nutritional deficiencies (El Hioui, 2009; Ngonde-Essome et al., 2017).

At the same time, the effects linked to anaemia in children seem important since it: increases their risk of dying (Brabin et al., 2001); influences their physical growth, their cognitive development, their reproductive capacity and their ability to do physical work (Ali Zinebi et al., 2017; Tchoukou, 2018), which therefore leads to a drop in performance. These effects are likely to delay the achievement of targets 3.2 and 4.2 of the

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VII Issue X October 2023

Sustainable Development Goals (SDGs).

According to estimates by the World Health Organization (WHO), 1.62 billion people have been affected by anaemia in the world between 1993-2005, with South Asia and Africa being the most affected regions (WHO, 2005). In developing countries, 42% of children under 5 years old and 53% of children aged 5-14 have anaemia (Tolentino and Friedman, 2007). Stevens et al. (2013) note that for every 100 children under the age of 5, 43 in the world, 54 in Africa and 67 in Sub-Saharan Africa suffer from this pathology.

Cameroon is no exception to this pandemic situation. Data from Demographic and Health Surveys (DHS) indicate that the prevalence of anaemia in children aged 6-59 months has increased from 68% in 2004 to 60% in 2011 and 58% in 2018 (INS and ICF International, 2004; INS and UNICEF, 2011 and INS and ICF International 2018). Over a period of 14 years, the combined efforts of the government and its partners in the field of child health have only been able to lower the prevalence of anaemia in Cameroon by 10 percentage points, i.e. a reduction of less than 1% per year. This is already drawing attention to the effectiveness and efficiency of the policies put in place.

In addition, studies have shown that the situation is direr in the three Northern and Eastern regions of the country. Indeed, the prevalence of anaemia in children aged 6-59 months has gone from 75% to 60% in the Adamawa region, from 73% to 65% in the Eastern region, from 70% to 64% in the Far-North and from 67% to 57% in the Northern region between 2004-2018 (INS and ICF International 2018). The Northern regions of Cameroon (Adamawa, North and Far-North) are the poorest regions when compared to other regions (Centre, Littoral, North-West, West, Southand South-West). All the health indicators are red, especially those relating to anaemia (IRAD, 2020) and the prevalence of anaemia is higher than the national average. Thus, it's important to study the phenomenon in these parts of the country in order to understand their peculiarities.

Several previous studies have attempted to address the issue dealing with anaemia in various fields including medicine, epidemiology, demography, etc. (El Hioui et al., 2009; Hamdouchi, 2009; Stella, 2011; Ngonde-Essome et al., 2017; Nogue, 2017; Djiguiba, 2020). Although these studies provide important information on the risk factors for contracting anaemia, they nevertheless have some limitations that need to be improved. Indeed, the limitations of these studies are from a methodological and sociological perspectives. On the one hand, the authors distinctly could not (if not very little) take into account the individual and contextual factors and their interrelationships in a single model. Their studies focused either on the diagnoses, or on the etiological factors, or even on the methods of treatment of anaemia using classic regressions. On the other hand, they have slightly failed in choosing and operationalizing the explanatory variables which make it possible to understand the phenomenon and the social factors with which it interacts or at least to grasp the interest of highlighting the behavioral approach of parents (mother's reproductive life experience, duration of breastfeeding of the child). The objective of this article is to overcome all these limitations by comparatively analyzing the explanatory factors of the three Northern and Eastern regions of Cameroon, in order to better understand the specificities of each of these two zones of the country at different levels of analysis (individual, household and community).

DATA AND METHODS

Sample

The data for the study come from the fifth Cameroon DHS carried out by the National Institute of Statistics (INS), in close collaboration with the Ministry of Public Health of Cameroon and with technical assistance from the American firm ICF which is piloting the World Demographic and Health Surveys Program. The said survey conducted from June 16, 2018 to January 19, 2019 is not representative of all regions due to the

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VII Issue X October 2023

security context in the English-speaking regions (North-West and South-West). Nevertheless, it gives a global picture of the urban situation in Cameroon

The primary objective of this DHS is to provide updated indicators on the economic and health situation. It also provides indicators useful for program monitoring and evaluation. More specifically, the DHS aim to collect data at the national and regional level to estimate the levels of indicators on several themes, including maternal and child health, in particular anaemia and the nutritional status of women and children under 5.

The study population consists of all the children aged 6-59 months residing on the date of the survey in Cameroon and who have undergone hemoglobin tests. Thus, 3,976 children were sampled. Moreover, the choice of the said population is based on the non-availability (in the different databases) of information relating to hemoglobin tests of children under 6 months of age owing to the diagnostic sensitivity associated to the great variability of hemoglobin in their blood.

Statistical Methods

The study is essentially based on the multilevel logistic regression. The relevance of this model is that: it introduces several sources of random variation; responds to the issue of the relationships between individuals and their environment; measures the effects of the environment on individuals; aggregates data collected at different levels in a single model, etc. In general, compared to classical regression, multilevel logistic regression reduces two types of error: statistical and interpretation (atomic effects and ecological effects). Ecological errors, for instance, are linked to the interpretation of aggregated results at the individual level, while atomic errors reflect the fact that the explanation of events at the individual level by only the characteristics of the individual consists in taking the individual out of its context. Moreover, the higher the levels of study, the more acceptable the results. In this article, we will distinguish three hierarchical levels i.e. children nested in households and those nested in communities (Rwenge and Njingouo, 2021). In total, five models have been estimated for this purpose.

The first model is the null or unconditional model or variance decomposition model (M0), is used to test the relevance of taking context effects into account in the regression. To highlight this effect, the model provides the initial distribution of the variance between the different levels, thanks to the random terms included in each of them. The null model makes it possible to decompose the total variance of anaemia and to highlight the portion of the variance attributable to households and that attributable to the characteristics of the regions (inter-regional variance). However, it does not include any explanatory variable. The equation for applying this model is given as:

$$\mathrm{L}\,(Y_{ijk}) = \ln\left[\frac{\mathbf{P}(y_{ijk}=1)}{1-\mathbf{P}(y_{ijk}=1)}\right] = \beta_0 + u_{0k} + \varepsilon_{0ijk}, \text{ avec } v_k \sim \mathcal{N}(0, \boldsymbol{\sigma_v^2}) \text{ et } \varepsilon_{ijk} \sim \mathcal{N}(0, \pi^2/3).$$

The second model or the compound variance model (M1) is the one that corresponds to the introduction of the individual variables into the null model. The aim is to identify the effects of these variables on intergroup variability in the explanation of anaemia. The compound variance model aims to check whether the level 1 variables increase or reduce the intergroup variance of the null model:

$$Lo\,(Yijk) = \ln\left[\frac{\mathbf{P}(y_{ijk}=1)}{1-\mathbf{P}(y_{ijk}=1)}\right] = \beta_0 + u_{0k} + \varepsilon_{0ijk} + \beta_1 V_{1ij} + \beta_2 V_{2ij} + \ldots + \beta_n V_{nij}$$

The third model (M2) is obtained by introducing characteristics relating to the family environment (level 2 variables) into the null model. It thus makes it possible to identify the fixed effect of each of these variables

on the risk of anaemia infection in children. It is given as:

$$Lo\ (Y_{ijk}) = \mathbf{ln}[\frac{\mathbf{P}(y_{ijk}=\mathbf{1})}{\mathbf{1}-\mathbf{P}(y_{ijk}=\mathbf{1})}] = \beta_0 + u_{0k} + \varepsilon_{0ijk} + \alpha_1 C_{1j} + \alpha_2 C_{2j} + \ldots$$

The fourth model (M3) is obtained by introducing community characteristics into the null model. It makes it possible to identify the fixed effect of each of these characteristics on the prevalence of anaemia in children**:**

$$(Yij) = \beta_0 + u_{0k} + \varepsilon_{0ijk} + \mu_1 X_{1k} + \mu_2 X_{2k} + \ldots$$

The complete model (M4) includes all the independent variables of the study, i.e. the variables of different levels of aggregation. It will make it possible to assess and identify the individual and contextual risk factors for contracting anaemia in the target population. Its formula is written as:

$$Logit(Y_{ijk}) = \mathbf{ln}[\frac{\mathbf{P}(y_{ijk}=\mathbf{1})}{\mathbf{1}-\mathbf{P}(y_{ijk}=\mathbf{1})}] = \beta 0 + \beta \mathrm{V}ijk + \alpha \mathrm{C}jk + \mu \mathrm{X}k + u0k + \varepsilon 0ijk$$

with i, j and k indices respectively describing the observations of level 1, level 2 and level 3 (community level); $Yijk$ represents the dependent variable (anaemic state or not of child i residing in household j which is located in region k; j; u0k: the residual at groups' level; $\varepsilon 0ijk$ is the residual at the level of individuals i of the household j belonging to community k.

VARIABLES

The dependent variable of the study is the anaemic state of the child on the date of the survey. Anaemia was measured by the hemoglobin level. In DHS, hemoglobin levels were measured using a Hemo Cu eHb 201+ device from finger-stick blood samples which were then used to determine the prevalence of anemia in children. Depending on the amount of hemoglobin available in the blood, the anaemic state comprises, in accordance with the thresholds defined by the WHO, four categories which are: severe, moderate, mild and non-anaemic. In this study, the anaemic state was regrouped into two categories: anaemic and non-anaemic. The first category takes into account all children suffering from different types of anaemia and the last, non-anaemic children.

Several independent variables were selectedbe itat the community, household or individual level:

At the community level, the type of place of residence was selected to determine the influence of the characteristics of each area (urban or rural) on the prevalence of anaemia in children aged 6-59 months in the study regions. The urban environment differs from the rural environment in terms of basic social infrastructure, schooling, religious affiliation, etc. This variable is measured in terms of urban and rural.

The proportion of poor households in the community, on the other hand, was considered to determine the level of poverty, which estimates the standard of living of the population in a community. The level of poverty has two categories in this study: poor and very poor. The first category refers to communities containing less than 50% of poor households while the second category refers to those containing more than 50% of poor households. Also, a community refers to a social group made up of people interacting with each other and sharing certain socio-cultural, demographic and economic characteristics.

The proportion of educated women in the community was considered in this analysis because of the role that educated women play in the society, and in their households in particular. Educated women tend to control the diet and health of their children. Based on this, the proportion of educated women at the community

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VII Issue X October 2023

level makes it possible to influence the occurrence of anaemia within the target population of the study. This variable has two categories: low and high. These terms respectfully refer to communities with less than 50% of educated women and those with more than 50% of educated women.

The level of immunization coverage of children in the community used in this analysis is a composite variable constructed from several variables, in accordance with WHO recommendations within the framework of the Expanded Program on Immunization (EPI). The EPI in Cameroon essentially aims to prevent, control, eliminate or eradicate vaccine-preventable diseases with a view to contributing to the reduction of infant and child morbidity and mortality. In view of the above, the immunization status of the child is constructed in this study from nine variables (BCG, Polio 0, Polio 1, Polio 2, Polio 3, DTCoq 1, DTCoq 2, DTCoq 3 and vaccine against -measles).The level of immunization coverage for children has two categories: low and high. The first category refers to communities with a higher than median proportion and the second to those with less than median proportion of children who have received all vaccines.

At the household level, several explanatory variables were used. These are variables relating to the socio-cultural, socio-economic and the family environment situation. The households concerned are precisely those in which the biometric tests were carried out.

The level of education of the household head was used to capture the perceptions of thevalues and considerations, the treatments that the household head can adopt towards those who reside in the household. This variable consists of three categories: without level of education, primary and secondary and more.

The main activity of the household head was used in order to better measure the economic activity. This variable often determines household'spurchasing and spending powers. This variable is grouped into four categories according to the tasks performed, which are; inactive, employee, farmers and traders.

The standard of living of the household is a composite variable that measures its financial capacity to obtain food in sufficient quantity as well as goods and services conducive to health and to contribute to the hygiene of its living environment (Kuaté Defo, 1997). In the 2018 DHS, it is determined on the basis of quintiles of economic well-being. Indeed, the standard of living is determined in the literature from two approaches: one accounting for monetary poverty (generally used by the World Bank to assess poverty under the viewpoint of consumption or income) and the other measured in the light of information relating to the mode of water supply, the type of toilet, the modes of lighting, the household equipment and the materials of the soil. Due to the sensitivity associated with the collection of information on minimum vital needs in the Cameroonian context and the difficulty of measuring poverty from a consumer goods viewpoint, a choice is made on the methodology used by the DHS- 2018. The standard of living of the household presented in quintiles of economic well-being is grouped into 3 categories: low, medium and high.

The source of drinking water supply was considered to provide an indication of the safety of the water consumed by household members and their exposure to waterborne diseases (INS and ICF international, 2018). It was grouped into two categories: improved (tap, pump well or borehole, protected/secured dug wells, protected spring) and unimproved (water from unprotected wells, unprotected spring water, sur+ face water, etc.).

The type of toilet was taken into account to understand the child's immediate environment. It is a variable that has several categories. However, in this study, it is grouped into two categories: improved (flush toilets connected to a sewage system or a septic tank, improved ventilated pit latrines, pit latrines with slab and toilets with composting) and unimproved.

At the individual level, the independent variables essentially refer to the individual characteristics of the mother and those of the child.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VII Issue X October 2023

The anaemic state of the mother was equally used in this analysis. It refers to qualifiers dedicated to hemoglobin levels in the blood to characterize anaemia in mothers. It refers to mothers with children aged 6-59 months mainly. As mentioned at the level of the dependent variable, the anaemic state of the mother will be grouped into two categories: anaemic and non-anaemic.

The mother's age at childbirth was considered to provide an idea of the mother's physiological maturity at the time of childbirth as well as her experience with feeding and health care practices.In the context of the study, this variable is constructed from two variables: the age of the mother and the age of the child at the time of the survey. The age of the mother at childbirth is obtained by taking the difference between the age of the mother and the age of the child on the date of the survey. It includes three categories: 15-24 years (young), 24-34 years (adults) and 35 years and over (old).

The level of education of the mother was used in this study to capture the health and nutritional behaviors of the mother, which are more often determined by her level of education. This variable was operationalized in this study in three categories: no level, primary, secondary and more.

The mother's reproductive life experience was also considered in the study to take into account the physiological, moral and biological immaturity of young mothers. It assumes that mothers who have already given birth have acquired a certain number of experiences in terms of care and control of the child's health. The mother's reproductive experience consists of three categories: no experience (mothers with 1 child), moderately experienced (mothers with 2 to 4 children) and more experienced (mothers with 5 or more children).

The nutritional status of the child is measured by the weight-for-age index. Weight-for-age is a combined index of height-for-age and weight-for-height that measures underweight. Weight-for-age reflects acute and chronic malnutrition. In this study, nutritional status has two categories: well-nourished and malnourished. Children whose Z-score for weight-for-age is below minus 2 standard deviations (-2SD) from the median of the reference population are considered malnourished and those whose Z-score is above minus 2 standard deviations (-2SD) from the median are the well-nourished.

The duration of breast feeding was also a key variable captured by this study, since infants obtain most of the nutrients the body needs for its proper functioning through the consumption of breast milk. Children who have not received breast milk from their mothers for any reason are at risk of disease, including anaemia. The duration of breastfeeding was categorized as follows: never been breastfed, 6-11 months and 12 months and more.

The age of the child was grouped into two: 6-23 months and 24-59 months. Sex: refers to the biological characteristics that defines human beings as male or female. In Africa and even more in Demography, the sex of the child is a dichotomous variable which has two categories: male andfemale.

Iron supplementation: it has two categories which are: yes and no

RESULTS

The results of the estimation of the null model show that the inter-group and intra-group variances are significant, regardless of the region considered. Therefore, taking into account the community and the family environment significantly improves knowledge on the determinants of anaemia in Cameroon. The analysis of the intragroup correlation coefficient reveals the existence of homogeneity between the children of the same group (family environment or community). The results also show an insignificant proportion (10.1%) of the prevalence of anaemia attributable to community characteristics and about 29.0% of the

prevalence of anaemia is explained by family characteristics in the three Northern regions of the country. This proportions is almost similar to those in the Eastern regions where we note respectively 9.0% and 29.7%.Overall, it can be said that the observed differences between children as far as the prevalence of anemia is concerned are largely attributable to unobserved factors at the household level and to a lesser extent to unobserved factors at the "community" level.

For each region considered, the probability associated with Wald's Chi-square in model 1 obtained after the introduction of individual characteristics in the null model turns out to be less than 1%. This indicates that these characteristics explain the prevalence of anaemia in children. Thus, the changes in the variances observed at the community level indicate that these characteristics explain approximately 16.4%(1,792-1,567/1,567*100) in the three Northern regions and 10.7% in the Eastern region of the heterogeneity not observed in the first level. This means that the said characteristics reduce the unexplained variance at this level by almost 16% and 11% respectively. This is similarin the Eastern region where the results show a reduction in the residual variance at the household level of about 15.3%. However, we note an increase of around 14.4% in the residual variance at the household level in the three Northern regions of the country. This increase indicates that the variability at the household level is partly explained by the composition effect.

The risks of contracting anaemia among children are determined by the discrimination effects between children in each part of the country. The effects of the mother's reproductive life experience and iron supplementation on children's risk of exposure to anaemia were found to be insignificant in all the regions studied. Also, the effects of the mother's age, the sex of the child on the child's risks of exposure to anaemia were found to be insignificant at the 5% level of confidence in all the regions studied, except that in the Eastern region, it appears nevertheless that female children and those from elderly mothers were found to be significant at 10% with lower risks of contracting anaemia.

Moreover, the individual characteristics relating to the parents indicate that the risk of contracting anaemia by a child of an anaemic mother is about twice as high as that of his counterpart whose mother is not anaemic in the three Northern as in the Eastern regions (OR=2.288 and OR=1.930 respectively). Children are more exposed to the risk of contracting anaemia as the level of education of the mother drops in the three Northern regions (36.5% less risk in a child of a mother with at least a secondary education comparedto one whose mother is uneducated). These differences are pronounced between the children of mothers with primary level and those of the reference category (i.e. 43.3% less risk) in the Eastern region

With regard to other characteristics specific to the child, the effect of the duration of breast-feeding on the prevalence of anaemia is not apparent in the three Northern regions, contrary to what prevails in the Eastern region where a child who has been breastfed for more than 12 months is 34.9% less likely to contract anaemia. The same is true for the nutritional status of the child. A malnourished child in the three northern regions is 1.438 times more likely to suffer from anaemia. However, the effect of the age of the child is felt in the three Northern as well as in the Eastern region, decreasing significantly with age (OR=3.541 in the three Northern regions and OR=3.404 in the Eastern region for children aged 6 to 23 months compared to their counterpart aged 24 to 59 months).

Taking into account the variables relating to the family environment reveals that the latter reduce by 18.5% and by approximately 30.3% the heterogeneity not observed at the community level and by 0.8% and 1.2% that of the household level respectively in the three Northern and Eastern regions. These variables weakly explain the differences observed between households and moderately between communities. It appears that in the three Northern regions, children from households managed by farmers (female farmers) are less likely (38.8% less) not to suffer from anaemia, which is not the case in the Eastern region where the analysis reveals the non-association between type of activity of the household head and child's anaemic state. Also, the standard of living of the household is also inversely related to the child's anaemic state. Thus, it is

negative in the Eastern region with 2,370 times more risks in children where it is low (poor) compared to those for whom it is high (rich) and remains without effect in the three Northern regions. However, the level of education of the household head, the source of drinking water supply and the type of toilet in the household are not significantly associated with the anaemic state of the child, regardless of the region considered.

The introduction of community variables in the null model significantly improves (on the basis of the Chi-2 test)the knowledge on children's exposure to anaemia at the 5% level of significance in the two parts of Cameroon. The present model resulting from the introduction of these variables reveals that they reduce the heterogeneity not observed at the level considered by 34.7% and 49.8% respectively in the three Northern and Eastern regions in 2018. They also reduce at the household level by 1.6% in the Eastern region. However, there is a slight increase in variances in the three North at the same level. As a result, part of the variance (increase) is slightly explained by the composition effect. Thus, with the exception of the proportion of poor households in the community, all the other variables located at the last level of analysis explain the phenomenon studied in the Eastern region, unlike in the three Northern regions where these characteristics turn out to not be significantly non-associated with the anaemic state of the child.

Thus in the Eastern region, a child residing in a rural environment or residing in a community with a low proportion of educated women is respectively 1.506 and 5.103 times more likely to be affected by anemia than his/her counterpart in an urban environment and in the community having a small proportion of educated women. In a community where the level of immunization coverage is high, children are 47.2% more likely to not suffer from anaemia.

The probability associated with Wald's Chi-square in model 4 obtained after the introduction of individual and contextual characteristics in the null model turns out to be less than 1% in the 2018 DHS data both in the three Northern and in the Eastern region. Globally, contrary to the Eastern region where some changes occurred, it turns out that all the variables did not change in significance in the three Northern regions, except the level of education of the mother and the nutritional status of the child whose effects have been cleared. The elimination of the effects of these individual characteristics indicates that the contextual variables play the role of intermediation in the model.

At the same time, in the Eastern region of the country, we note that the individual characteristics of the mother besides her level of education, the individual characteristics of the child except child's sex and child's duration of breast-feeding; the meso variables except the standard of living of the household and those at the macro level except the type place of residence have maintained their influence on the anaemic state of the child. It happens that in this part of the country, the age of the mother, which was significant at the 10% level of significance, and the type place of residence at 10% no longer exert an effect on the occurrence of anaemia after introducing all the characteristics simultaneously in the model. Sex and duration of breast feeding increase in influence, going from 10% and 5% to 5% and 1% respectively. Contextual variables thus mediate their effect. However, the household standard of living remains the same, except that here the median category (mean) decreases in its influence. It then appears that the anaemic state of the child remains negatively associated with the household's standard of living.

Table 1: Net effects of the independent variables on the child's anaemic state in the three Northern and Eastern regions respectively

Variables		**M0**	**M1**	**M2**	**M3**	**M4**
Individual characteristics						
Individual characteristics relating to parents						
Age of the Mother						
Young	799		1,000			1,000

Adult	748		0,980^{ns}			1,010^{ns}
Aged	193		0,726^{ns}			0,755^{ns}
Anaemic state of the mother						
Non-anaemic	663		1,000			1,000
Anaemic	1 077		2,288***			2,228***
Level of education of the mother						
No level	803		1,000			1,000
Primary	616		0,737*			0,877^{ns}
Secondary education and plus	321		0,635**			0,880^{ns}
Mother's reproductive life experience						
No experience	197		1,000			1,000
Moderately experienced	827		1,122^{ns}			1,113^{ns}
more experienced	716		1,270^{ns}			1,311^{ns}
Individual characteristics relating to Children						
Duration of breastfeeding						
Never breastfed	224		1,000			1,000
6-11months	1 371		0,837^{ns}			0,843^{ns}
12 months or more	145		0,737^{ns}			0,755^{ns}
Age of the child						
6-23 months	619		3,541***			3,525***
24-59 months	1 121		1,000			1,000
Sex of the child						
Male	894		1,000			1,000
Female	846		0,860^{ns}			0,861^{ns}
Nutritional status of the child						
Well-nourished	1 419		1,000			1,000
Malnourished	321		1,438**			1,405*
Iron supplementation						
No	1 514		1,000			1,000
Yes	226		1,162^{ns}			1,368^{ns}
Household characteristics						
Level of education of the household head						
No level	751			1,000		1,000
Primary	530			0,823^{ns}		0,866^{ns}
Secondary and plus	459			0,896^{ns}		0,944^{ns}
Main activity of household head						
Not active	450			1,000		1,000
Employee	121			0,846^{ns}		1,177^{ns}
Farmer	895			0,612**		1,646**
Trader	274			0,823ns		1,011ns

Household standard of living						
Poor	1 190			1,000		1,000
Moderate	290			0,923^{ns}		1,561^{ns}
Rich	260			0,620^{ns}		1,259^{ns}
Source of drinking water supply						
Improved	892			1,000		1,000
Unimproved	848			1,300^{ns}		1,340*
Type of toilet						
Improved	612			0,809^{ns}		0,833^{ns}
Unimproved	1 128			1,000		1,000
Community variables						
Type of place of residence						
Urban	552				0,659^{ns}	0,642^{ns}
Rural	1 188				1,000	1,000
Proportion of poor households in the community						
Low	457				0,723^{ns}	0,558^{ns}
High	1 283				1,000	1,000
Proportion of educated women in the community						
Low	848				1,174^{ns}	0,975^{ns}
High	892				1,000	1,000
Level of immunization coverage in the community						
Low	1 669				1,000	1,000
High	71				0,623^{ns}	0,725^{ns}
Random section						
Var(cons[community])		1,722***	1,574***	1,557***	1,441**	1,558**
Var(cons[community>household])		4,791***	6,001***	4,730***	4,883***	5,653***
Chi2	***	***	100,353	22,232	18,215	115,503
Wald	***	***	100,35	22,23	18,22	115,50

Exponentiated coefficients

$^{ns}p< 1$, $^{*}p< 0,10$, $^{**}p< 0,05$, $^{***}p< 0,01$s

Variables		M0	M1	M2	M3	M4
Individual characteristics						
Individual characteristics associated with parents						
Age of the mother						
Young	887		1,000			1,000
Adult	1 043		0,963^{ns}			0,876^{ns}
Aged	306		0,720*			0,739^{ns}
Anaemic state of the mother						

Non-anaemic	1 408		1,000			1,000
Anaemic	828		1,930***			1,977***
Level of education of the mother						
No level	110		1,000			1,000
Primary	768		0,567***			0,654**
Secondary and more	1 358		0,792ns			0,952ns
Mother's reproductive life experience						
No experience	331		1,000			1,000
Moderately experienced	1 287		0,879ns			0,856ns
more experienced	618		1,157ns			1,045ns
Individual characteristics associated with children						
Age of the child						
6-23 months	787		3,404***			3,345***
24-59 months	1 449		1,000			1,000
Sex of the child						
Male	1 104		1,000			1,000
Female	1 132		0,758*			0,731**
Duration of breastfeeding						
Never breastfed	254		1,000			1,000
6-12months	1 659		0,891ns			0,952ns
13 months or plus	323		0,651**			0,627***
Iron supplementation						
No	1 732		1,000			1,000
Yes	504		0,839ns			0,877ns
Nutritional state of the child						
Well-nourished	2 140		1,000			1,000
Malnourished	96		1,639ns			1,441ns
Household characteristics						
Level of education of the household head						
No level	634			1,143ns		1,115ns
Primary	619			1,254ns		1,159ns
Secondary and more	983			1,000		1,000
Occupation of household head						
Not active	611			1,000		1,000
Employee	551			0,762ns		0,861ns
Farmer	585			0,753ns		0,782ns
Trader	489			0,818ns		0,939ns
Household standard of living						
Poor	516			2,370***		2,182***
Moderate	617			1,777***		1,615**
Rich	1 103			1,000		1,000

Source of drinking water supply						
Improved	1 102			0,915^{ns}		0,891^{ns}
Unimproved	1 134			1,000		1,000
Type of toilet						
Improved	1 369			1,000		1,000
Unimproved	867			1,121^{ns}		1,026^{ns}
Community characteristics						
Type of place of residence						
Urban	1 240				1,000	1,000
Rural	996				1,506**	1,080^{ns}
Proportion of poor households in the community						
Low	1 703				1,000	1,000
High	533				1,363^{ns}	0,970^{ns}
Proportion of educated women in the community						
Low	39				5,103**	4,397**
High	2 197				1,000	1,000
Level of immunization coverage in the community						
Low	1 893				1,000	1,000
High	343				0,528***	0,517***
Random section						
Var(cons[community])		1,622***	1,540***	1,401***	1,275**	1,261**
Var(cons[community>household])		4,932***	3,861***	4,842***	4,808***	3,788***
Chi2			135,366	35,393	33,866	164,313
Wald			135,37	35,39	33,87	164,31

Exponentiated coefficients

$^{ns}p< 1$, $^{*}p< 0,10$, $^{**}p< 0,05$, $^{***}p< 0,01$

DISCUSSIONS AND CONCLUSION

The results of the descriptive analysis revealed that about 2 out of 3 children aged 6-59 months in the three Northern regions are anaemic, unlike in the Eastern region where this figure was half in 2018. Also, the different regressions have made it possible to understand the main factors that determine anaemia and their regional disparities. However, the formulation of these explanatory factors remains insufficient if they are not interpreted and understood within a very specific context. Indeed, several previous studies have tried to measure the main mechanisms that influence anaemia in children in the African context and in various fields. Thus, to better understand the results presented above, it is necessary to establish discussions based on the context of the study and the literature review.

The anaemic state of the mother is an explanatory factor of the anaemic state of the child both in the three Northern and Eastern region. This result is in line with the results ofprevious studies, such as those of Tchoukou (2018), Yelbi (2018). Folquet Amorissani and his colleagues (2007) observed, for example, in their study of 241 premature babies in Ivory Coast that the anaemic state of the mother negatively influences the probability that a child will be non-anaemic. According to these researchers, children whose mothers have not benefited from her prophylaxis program against anaemia and malaria are more likely to present

symptoms of early anemia. Indeed, the level of iron stores in a child also depends on the child's iron status at birth (Chaparro, 2008). During the first two trimesters of pregnancy, iron deficiency anaemia increases the risk of premature birth and low birth weight (Brabin et al., 2001a) which is strongly linked to the morbid state of the child (Ouedraogo , 2013) and anaemia in particular (Tchoukou, 2018).

Another result of the study shows the level of education of the mother as a determinant of anaemia in the study areas. In the Eastern region, a child whose mother has at least a secondary level is not significantly different from that of an uneducated mother, unlike one whose mother has a primary level which differs significantly with 43.3% more chance of not being afflicted with anaemia as the latter. In general, women with a secondary level and above in this part often do not have time to take care of children or at least to leave them under the care of "maids" because of the difficulties (responsibilities) they encounter in the work or habits. However, in the three Northern regions, it turns out that the level of education of the mother is negatively associated with the anaemic state of the child. Thus, the more the level of education of the mother increases, the more the child tends not to run the risk of contracting anaemia. This situation already brings forth the ability of an educated mother to take care of her children (Ndour et al., 2019). Indeed, the more a mother is educated, the more she is cautious of the health of her children and of course, does not delay in taking her child to a health facility when there is appearance of a small symptom (Ndour et al., 2019). Moreover, the influence of the mother's education cannot only be limited to her health knowledge. It ranges from factors which are entrenched in her status as a mother to her decision-making power in the household (Cadwell, 1979).

The study also reveals the duration of breastfeeding as a determinant of anaemia in children in the Eastern region. Thus, children who have never been breastfed have a greater risk of being anaemic than those who have been breastfed for more than 13 months. Breast milk is the main source of nutrients for the child, recognized for its role in providing antibodies and all the nutrients from the mother to the child. However, the results revealed that the impact of the duration of breastfeeding differs from the three Northern regions to the Eastern region and brings into play several other factors responsible for the balance of infant and child health in the three Northern regions of the country. Another aspect of the study reveals the nutritional status of the child as being insignificant in explaining anaemia in the Eastern region, unlike in the three Northern regions where malnourished children have 1.438 times more risks of being affected with anaemia.It seems clear that in the Eastern region, most children benefit from health care, and in particular from the Extended Program on Immunization and the fight against malaria, the importance of which in relation to anaemia has been highlighted in the literature (Mukuna et al. ., 2020; Salif Djiguiba, 2020).

The study also shows that a child aged 6-23 months is significantly more likely to be anaemic than his counter part aged 24-59 months in the two "zones". These results are consistent with those obtained in the Cameroon DHS III, IV and V and other work carried out by Diouf et al. (2015), Eleké et al. (2021). Everything seems that the period following the first six months of life is the beginning of the introduction of food to the child (period of transition between breast milk and ordinary family food) and also marks a period of strong bone development. Thus, iron needs become important, and an inadequate diet surely predisposes the child's body to pathological attacks, and to anaemia in particular.

The sex of the child is not a discriminating factor in 2018 even if a slight difference seems to be observed in the East where at 10% level of significance, girls have lesser risk of being affected by anaemia. Thus, many previous works have shown that sex is not a determinant of anaemia (El Hioui et al., 2009; Yelbi, 2018; Eleké et al., 2021).

Moreover, the occupation of the household head was found to have a significant influence on the anaemic state of the child in 2018 in the three Northern regions. Children residing in households where the household head is a farmer have 39% less risk than those livingin households where the household head is without any activity. However, the study did not reveal any difference between children in the reference category and those living in households whose heads are employees or traders. Farmers are essentially providers of

products of enormous necessities likely to alleviate food problems. As for traders and employees, the absence of differences may be closely linked to the lack of family control and to the activities of the nannies of these target children of the study for whom they are responsible. This explanation elucidates the non-correlation between the occupation of the household head and the anaemic state of the child in the East.

In the East, the risk for children of contracting anaemia is greater when the standard of living decreases. This negative association is in line with the observations made by Tchoukou (2018), Yelbi (2018) and Mohammad Hifz (2020). According to these researchers children living in poor households (lowest quintile respectively) are more likely to suffer from anaemia than their peers from wealthy households (respectively from the highest quintile). Indeed, several studies have shown that anaemia is a pathology linked to the child's environment, the standard of living of households with poverty and even the choice of food, hygiene with the supply of drinking water (Ndour et al, 2019), since the socio-economic status of the household determines its food availability and living conditions (Yip, 1997). However, this correlation shown in the East has not been demonstrated in three Northern regions of Cameroon in 2018.

The study reveals that the type of place of residence, the proportion of poor households and the level of immunization coverage in the community determine the occurrence of anaemia in the Eastern region, while they remain without effects in the three Northern regions of the country. Indeed, the absence of differences between the children according to the context of residence or the characteristics of the communities in the North is due to the improvement in the standard of living resulting from several synergistic actions, the promotion of an adequately diversified improvement more visible in rural areas and possibly in the northern regions. We can note the program to fight against acute malnutrition in connection with Cameroon's national policy in the Far North region by the French Red Cross (CRF) and that of the Cameroon Red Cross (CRC) in 2014, some response campaigns against certain epidemics in the targeted areas of the North in 2016, etc.

The study made it possible to identify the profile of children at risk of contracting anaemia, the determinants of this pathology at three levels of analysis namely: Individual, Meso and Community levels in the three Northern and Eastern regions of Cameroon. It emerges that at the first level, joint efforts should focus on the health and education of women in all the study regions. Public authorities would benefit from focusing on children aged 6-23 months regardless of the region of study. To do this, a vitamin A supplementation program is required. In the three Northern regions, the fight against malnutrition could be envisaged through raising awareness on food and nutritional practices. On the other hand, it would be relevant in the East to space births, to encourage breastfeeding with breast milk. At the meso level, it is recommendedthe improvement of the standard of living of households in the Eastern region, while a vast awareness-raising campaign for households' heads on anaemia in relation to their main activity should be encouraged in the three Northern regions. The study in no way recommends what should be applied in the three Northern regions, but underlines that in the East, the usefulness of promoting the media to encourage the local population, and in particular of the rural areas, on the need to scale-up the Extended Program on Immunization.

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