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A multilevel approach to correlates of anaemia in women in the Democratic Republic of Congo: Findings from a nationally representative survey

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Abstract

Background: Anaemia accounts for a significant proportion of pre- and post-partum morbidity and mortality in low-income countries with sequelae including an increased risk of infection. Factors contributing to anaemia need to be addressed through the introduction of evidence-based measures to control and prevent the disease. We aimed to determine the prevalence of anaemia in women of child-bearing age in the Democratic Republic of Congo (DRC) and investigate the associated individual, household and community level factors.

Methods: Cross sectional representative population data from the 2013-2014 DRC Demographic and Health Survey (DHS) was used. The primary outcome was anaemia in women, stratified according to pregnancy in those of child-bearing age. A haemoglobin level of below 11g/dl for pregnant women and 12g/dl for non-pregnant women was used as the indicator of anaemia. Using a three-level random intercept model this study explored risk factors at individual, household and community levels and quantified the observed and unobserved variations between households and communities.

Results: Thirty eight percent of women in the DRC are anaemic. Anaemia is significantly higher in younger, pregnant and underweight women, as well as those with comorbidities including HIV and malaria who are living in the capital city Kinshasa. Anaemia varies within and between households and communities in the DRC.

Conclusion: Integrated approaches to reduce anaemia in settings with high malaria and HIV prevalence such the DRC should target households.

Key words: Anaemia, prevalence, DRC and risk factors

Introduction

Background

Anaemia is a worldwide public health problem [1], with an estimated 25% of the world's population (1.62 billion people) suffering from the condition [2, 3]. Prevalence data indicates that 90% of those that are anaemic live in low income countries, with children under 5 years and women of child-bearing age most affected [4]. There are large variations in prevalence both within and between countries [5, 6], with a prevalence of over 40% identified as being of severe public health concern according to the World Health Organisation [7]. A prevalence of 5-19.9% is considered of 'mild' public health significance and 'moderate' public health significance is reported when anaemia reaches 20 to 39.9% of the population [7]. The illness is diagnosed when haemoglobin levels fall below 12g/dl in adult non-pregnant women and below 11g/dl during pregnancy [8].

Causes of Anaemia

The causes of anaemia are multifactorial and can be studied at a number of levels. The immediate causes are mainly attributable to micronutrient deficiencies involving iron, vitamin B12, or folic acid, with recent studies suggesting that iron deficiency accounts for 25% of anaemias in pre-school children and 37% in non-pregnant women of childbearing age [1, 9]. Insufficient dietary intake is a common cause of anaemia [10], termed nutritional anaemia. This is seen when the demands for synthesis of haemoglobin are not met through the diet. Further, there is considerable epidemiological research associating low body weight and haemoglobin levels [11] although indirect factors such as Minimum Dietary Diversity for Women (MDD-W) play an important role [12].

Other immediate causes of anaemia include physiological adaptations during pregnancy or breastfeeding, and infections such as malaria, hookworm and HIV [9]. Women face specific issues with anaemia due to pregnancy, childbirth and breastfeeding. During pregnancy, anaemia is associated with deleterious outcomes for the child including poor motor and mental performance in children, and in the extreme, maternal and child death [13]. Childbirth can lead to anaemia particularly following post-partum haemorrhage or when poor maternal nutrition cannot be resolved through diet [14]. Anaemia is common during lactation, especially following anaemia in pregnancy [15].

Malaria causes anaemia through the destruction of erythrocytes whilst retaining iron stores [1, 16], with the iron contained within infected red cells providing important nutrients for the developing malarial parasites [17]. The DRC has 55% of all malaria cases in central Africa [18].

Hookworm is also common in DRC, although there are limited studies on this topic. Hookworm infection is related to anaemia [19], as hookworms reside in the small intestines of infected individuals where they attach themselves to the villi causing blood loss and anaemia [13, 20, 21].

Although HIV is at low levels in DRC (0.7% prevalence amongst adults aged 15-49), amongst women who are infected opportunistic infections and AIDS related malignancies may lead to anaemia as the disease progresses [22]. Furthermore, drug treatment can also produce toxic effects leading to anaemia [23].

Besides these immediate risk factors of anaemia, there are ranges of known distal factors that operate at the household and community levels [1]. These include education status, household sanitation and hygiene, source of drinking water and rural/urban residence [7]. Each of these factors is associated with anaemia prevalence amongst women of reproductive age and the pathway through which each factors is associated with anaemia is clear [1]. For instance, women without access to clean water might have higher prevalence of anaemia due to inflammation caused by intestinal infections [14], diarrhoea or intestinal bleeding. Educational status is also known to be associated with diet, with those with higher levels of education reporting a better diet [24].

This paper describes the prevalence of anaemia in women in the Democratic Republic of Congo (DRC) and investigates individual, household and community level risk factors in this group. It explores the multiple contributing factors of anaemia, based on country level representative data, and hence can be used to aid in the design of prevention and control policies.

Data and Methods

Data

The Democratic Republic of Congo 2013-14 Demographic and Health Survey (DRC-DHS) data was used for this research. The sample design involved a probabilistic two-stage sampling, dividing the country into urban and rural areas, stratums (districts) and then clusters (villages). Random households were selected randomly from these clusters. All woman aged 15 to 49 residing in every third selected household were tested for anaemia. Details of the sampling and selection process are published in the DHS Country report [25]. This analysis focused on women aged 15 to 49 who were tested for anaemia as depicted in Figure 1.

--- Figure 1 about here ---

Outcome and explanatory variables

Anaemia was the chosen outcome variable for this study, with potential socioeconomic and demographic risk factors selected as predictors at the individual, household and community levels (listed in Table 1).

---Table 1 about here---

Individual level factors included age, pregnancy status, currently breastfeeding, whether suffering from malaria (as assessed by a blood smear evaluation), HIV status (as tested in a laboratory) and Body Mass Index (BMI). A proxy variable was computed to indicate the potential presence of infection. If an individual tested positive for both HIV and malaria then an infection was assumed.

A binary indicator for MDD-W was constructed. Using the assumption that women are likely to consume the same meal as their children, the food consumed by a child was used to calculate MDD-W, defined as the consumption of at least five out of ten defined food groups. This was derived using the Food and Nutrition Technical Assistance (FANTA) approach, and food given to children [26].

Foods were grouped into 10 categories:

(1) Grains, white roots and tubers, and plantains (bread, noodle, grain, tubes, potatoes and cassava)
(2) Pulses (beans, peas and lentils);
(3) Nuts and seeds;
(4) Dairy food including cheese, yogurt and milk products;
(5) Meat, poultry and fish (chicken, pork or beef meat, liver, heart and fish);
(6) Eggs;
(7) Dark green leafy vegetables;
(8) Other vitamin A-rich fruits and vegetables (vitamins; fruits pumpkin, carrot, mango and papaya);
(9) Other vegetables;
(10) Other fruits.

The MDD-W was computed first by summing the groups into a score ranging from 0 to 10, with an acceptable MDD-W taken as score of ≥ 5.

From the measured height and weight of the women, BMI was calculated and categorised using the international classification of BMI for adults [27]. Three groups were used: underweight ((BMI <18.50 kg/m^2), normal (BMI=18.5 to 24.99 kg/m^2) and overweight and obese (BMI> 25kg/m^2). The final category was grouped due to small number of cases.

Further individual level factors included the woman's level of education and their occupation, categorised by the sector of the work (sales, agriculture or other). Marital status was also used.

There were two factors used at the household level: wealth status and the source of drinking water. Wealth was derived from the assets that were recorded within the household and divided into quintiles. The source of drinking water was recoded into two groups: improved (piped combined with protected spring) and unimproved (well combined with unprotected spring, dam or others). Community level factors included the place of residence and the region.

Statistical Analysis

Multilevel logistic regression models accounted for the complex sampling design and were warranted as the clustered sample design violates the assumption of independence required in standard logistic regression. Clusters reduce independence between individuals due to unobserved common influences such as shared beliefs concerning food, cultural practices, and use of health services [28]. If this is not accounted for then models may underestimate standard errors and overestimate the significance of some variables [29].

A combination of forward model selection, practicality, and the principle of coherency were used to select the models. Variables were entered sequentially after individual testing. Initial models were fitted testing the first explanatory variable. If the variable was significant at the 5% significance level (two sided p-value), a second predictor was added to the model. An interaction term was considered when deemed meaningful/necessary and where it is believed that the significant variables might have a different effect on anaemia dependent on the categories of the other variable.

Survey weight analysis

Survey weights were employed during the bivariate analysis to ensure representativeness and to account for non-response. Due to the limited availability of software packages weights were not employed in the multilevel modelling and weights in the DHS datasets are provided at individual rather than at the required levels [30-32].

Results

Exploratory results using Pearson Chi-square

Table 1 presents exploratory results of the population sampled. Thirty-eight percent of the women sampled were anaemic. According to the WHO, this suggests that anaemia amongst women of reproductive age in the DRC is a moderate public health issue. Preliminary results indicate that BMI, pregnancy, malaria, HIV, education, source of drinking water and region are potential factors associated with anaemia, although these results do not account for the impact of other factors.

Results from univariate multilevel logistic regression models

Tables 2a to 2c present adjusted odds ratios and their associated 95% confidence intervals for the selected individual, household and community risk factors for anaemia in women. Independently, the univariate multilevel analysis suggest that age, BMI, pregnancy, malaria, HIV infection and region are factors associated with anaemia. Although women's level of education and the source of drinking water were statistically significant in the bivariate analysis (Table 1), these are not significant in the univariate analysis when unobserved random effects are accounted for (see Tables 2a, 2b and 2c).

---Tables 2a, 2b and 2c---

Results from multivariable three-level random intercept models

Multivariable multilevel analysis indicates that BMI, malaria, HIV, wealth, source of drinking water and region are significantly associated with anaemia in women of reproductive age in the DRC. The association between the variables age, pregnancy and anaemia were not statistically significant after controlling for other observed factors such BMI, and infections.

Body mass index: Anaemia varies significantly with women's BMI. The results suggest that women's odds of anaemia decrease with an increased BMI. Compared with underweight women, overweight combined with obese women are associated with 68% decreased odds of anaemia [OR (95% CI):0.32 (0.14, 0.74)].

Malaria and HIV: Women who have malaria or are HIV positive are much more likely to have anaemia than those who have not and this is statistically significant independently, after controlling for the effect of other individual level risk factors and even after controlling for all levels (individual, household and community) risk factors.

Infection: The results suggest that, after controlling for other observed risk factors of anaemia, women who have malaria and are HIV positive have a 7-fold increased odd of anaemia compared to their infection-free counterparts.

Wealth status: Household wealth is one of the household level factors associated with anaemia after the effect of source of water and random effects were accounted for. The results however, suggest that those in the richest quintile are 51 times more likely to have anaemia than those in the poorest quintile [OR (95% CI):1.51 (1.06, 2.14)].

Type of source of drinking water: the source of drinking water is another significant household level factor associated with anaemia in women in the DRC. Compare with women who drink from improved source of water, those who drink from unimproved sources are 26 times more likely to have anaemia [OR (95% CI): 1.26 (1.05 , 1.51)].

Region: the region is an important community level factor associated with anaemia among women in the DRC.

The results suggest that there is no association between anaemia and breastfeeding, MDD-W, occupation, marital status, and the place of residence.

Random effect results

The variability in women's likelihood of developing anaemia that could not be attributed to observed individual, household, and community factors, was tested and computed using three-level random intercept models considering three levels: individual, household and community. The results suggest that, in addition to the factors associated with anaemia previously presented, there are significant unobserved variations in the likelihood of anaemia due to the household characteristics and communities in which these women live. These unexplained variations are higher between households than they are between communities.

Discussion

This study uses country level, representative data to describe the prevalence of anaemia and to explore the individual, household and community factors associated with anaemia in women of reproductive age in DRC. Multilevel logistic regression models were used to account for observed and unobserved risk factors of anaemia and quantify differences due to households and communities in which those women live. The study identifies sub-groups of women at high risk of anaemia, and recommends public health interventions to prevent and reduce the burden of anaemia. The prevalence of anaemia in women in the DRC is 38%, making it a moderate public health problem according to WHO threshold [7]. The results suggest that BMI, malaria and HIV; wealth and source of drinking water and region are respectively individual, household and community risk factors associated with anaemia in women in the DRC. In addition, the prevalence of anaemia in women varies significantly between households and communities within the DRC.

There is a large fall in anaemia prevalence since 2007, which was 53% [33]. However, the prevalence in 2013 is high when compared against other Sub-Saharan (SSA) countries including, Rwanda (17%); Burundi (21%); Kenya (25%); Uganda (27%); Malawi (29%); and Zambia (29%) [27], presumably due, in part, to the ongoing political crisis in the DRC [40]. Anaemia prevalence is lower in these countries because their governments have invested in technical facilities, clean built environment, sustainable management of drinking/sewage water, improved sanitation and waste management in communities. Some of these countries also have a National Sanitation Day as a community participatory event which serves as an opportunity to promote community education about the benefits of a clean environment and good health [34]. Further, these countries, along with other SSA countries except the DRC, have adopted large-scale mandatory/voluntary food fortification programs, valuable tools for alleviating micronutrient deficiencies, along with other public measures to combat anaemia [35]. Anaemia is multifactorial; hence, reliance on single-food fortification in preference to the implementation of other public health measures to remedy the several determinants of persistent anaemia would be a mistake.

Infection is likely to be a large contributing factor of anaemia in the DRC due to high levels of malaria [36]. The country has the second largest numbers of malaria globally and previous studies indicate that malaria is the cause of anaemia especially in tropical countries [18, 36]. The WHO suggests that the prevalence of anaemia in women should be considered as a metric of malaria burden [37]. In addition, the significant interaction between malaria and HIV have significant public health implications (Table 2a) [37].

Anaemia is inversely correlated with BMI. Although overweight/obese (category also kwon as excessive fat accumulation) is another type of nutritional problem open for a debate that is beyond the scope of this paper, women who are overweight or obese are less likely to have anaemia. This is most likely linked to food intake and environmental and physiological factors [38-40].

This study has shown that the richest quintile are more likely to be anaemic than those in the poorest quintile. This is counter-intuitive as richer women are more likely to afford nutrient-rich food than the poorest. Most of the poorest women in the DRC are involved in subsistence agriculture, cultivating vegetables for consumption and income. Thus, it is possible that cultivating food reduces the odds of anaemia. However, when testing the variable "occupation", the results were statistically insignificant. The increased prevalence in the richest quintile is seen in the adjusted figures and was also seen in the previous DHS in 2007 [33]. Further investigation of this is needed.

The results are in line with previous studies suggesting that women without access to clean water are far more likely to have anaemia than those who drink from improved sources, due to inflammation/enteropathy [1, 41].

Women living in the capital city, Kinshasa, are twice as likely to be anaemic than those living in other regions of the DRC. Higher risk of anaemia in women from Kinshasa could be partially attributed to the scale of expansion in urban population growth, mostly due to rural-urban migration driven by insecurity in other regions of the country [42, 43]. Kinshasa and its peri-urban areas are characterised by overcrowding, with many families living in slums in dismal living condition, poor sanitation, especially open urination and defecation, with no management/treatment of sewage water. These conditions significantly disadvantage women living in urban areas due to the exposure to infections [44]. In addition, instability and political crises in the DRC have prevented the formal economy from reducing poverty whilst hunger, diseases, and poor health increase the risk of anaemia [45] . Food security is still challenging with limited availability of all food groups in most part of the country, including the capital Kinshasa [46].

Given that nutritional anaemia is the commonest cause of anaemia throughout the world, one would expect MDD-W to be amongst the main contributing factors of anaemia. However, the results from this study suggest that MDD-W is not. A key reason for this unexpected result may be the measurement used, MDD-W in this study is a proxy variable indirectly measured from children's diet and with lots of missing data. Surveys that collect information about adult food intake are needed to assess the link between food intake and anaemia in women in the DRC. This approach would also allow an initial disaggregation of types of anaemia by geographic region.

Although demonstrating some association using univariate multilevel analysis, the association between pregnancy and anaemia is diluted once other observed factors including malaria, HIV and unobserved factors are accounted for. Nevertheless, anaemia in pregnant women in the DRC is a severe public health problem, with 44% of pregnant women tested as anaemic. The WHO recommends that all pregnant women receive a standard daily dose of 30-60 mg iron and 400ug folic acid beginning as soon as possible during gestation, ideally no later than the first trimester of pregnancy [47, 48]. Available data suggests that antenatal care (ANC) coverage is relatively high in the DRC [25, 47, 49]. However, women's access to interventions that improve reproductive health and pregnancy outcomes during ANC is limited. For instance, in 2014 87% of pregnant women attended at least one ANC visit, 52% of those women received or purchased iron-folic acid but less than 1% received the proper dosage of 180+ tables [47, 49].

Hookworm infection due to geophagy, not accounted for in this study is another possible explanation for the high prevalence of anaemia during pregnancy. Some pregnant women in DRC and other African countries crave for soil; a craving similar to that of chocolate [28]. It is suggested that geophagy is a regular habit of 30% to 80% of women in Africa, with individuals consuming 100g to 400g daily [28]. Geophagy has been associated with increased incidence of intestinal parasites which may lead to anaemia [29]. Therefore deworming is recommended during pregnancy in the DRC [50].

Random effects: Significant random effects at household and community level imply the need for socio-ecological approach to reduce the burden of anaemia among women in the DRC, because health outcome such as anaemia can be shaped by the complex interplay between individual, household and community (environmental) factors [51].

Policy recommendations: The DRC should adopt socio-ecological approaches that create sustainable solution for at-risk individuals and communities in order to reduce the burden of anaemia. Public health policies should include sustainable investment in clean built environment throughout the country, allocation of resources for maternal and child health, improve drinking/sewage water, sanitation practices, refuse disposal, access to healthcare services and restricted policies for higher fees for health services, and nutritional programmes towards the broader context of women's family and communities within the DRC.

Study limitations: It was not possible to examine directly the link between anaemia in women and food intake due to the lack of information on women's food intake. A proxy variable, MDD-W indirectly measured from children's diet was used instead. Surveys, which collect information on food intake and anaemia for women of reproductive age, are need in the DRC.

Survey weights were not included in the three-level random intercept models because of limited availability of software packages and weights in the DHS data are not provided at higher levels. Nevertheless, results from this study are in agreement with previous findings and indicate were intervention is needed in order to reduce the burden of anaemia in women.

Further scope: Further studies will examine the link between anaemia and food intake while controlling for other risk factors of anaemia such as infections in children in the DRC and conduct implementation studies in order to reduce anaemia in the DRC.

Conclusions

This paper is evidence-based, derived from country data, and provides public health recommendations that can prevent and control anaemia in women in the DRC. The results indicate that anaemia in women in the DRC is a moderate public health problem and its prevalence is higher compared to many SSA countries. The results indicate that in the DRC infection, especially malaria is an important contributing factor to anaemia. Therefore, appropriate interventions are needed to reduce the haematologically deleterious impact of both infections and malaria.

Socio-ecological approaches are needed in order to reduce the burden of anaemia and these must be policy-enabling environment that are instigated at local and national levels. Equally, the DRC should adopt mandatory public health nutritional measures such as iron fortification of staple foods; appropriate doses of iron supplementation to high-risk groups; increased production and consumption of iron and other micronutrient rich foods.

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Author's contributions

NK formulated the research question and designed the study

NK performed statistical analysis.

NK, SP, NM, AC and GK wrote the paper

NK, SP, NM, GK and AC had primary responsibility for final content.

All authors have read and approved the final manuscript

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Conflict of Interest

None declared

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Figure and table legends

Table 1. Percentage of anaemia by potential explanatory factors in women in DRC

Table 2a. Estimated odds ratio (95% CI) of anaemia in women in DRC against individual level risk factors from the univariate and multivariable multilevel logistic regression models (N=9,885)

Table 2b. Estimated odds ratio (95% CI) of anaemia in women in DRC against household level risk factors from the univariate and multivariable multilevel logistic regression models (N=9,885)

Table 2c. Estimated odds ratio (95% CI) of anaemia in women in DRC against community level risk factors from the univariate and multivariable multilevel logistic regression models (N=9,885)

Figure 1. Modified CONSORT flow diagram of the analytic sample selection

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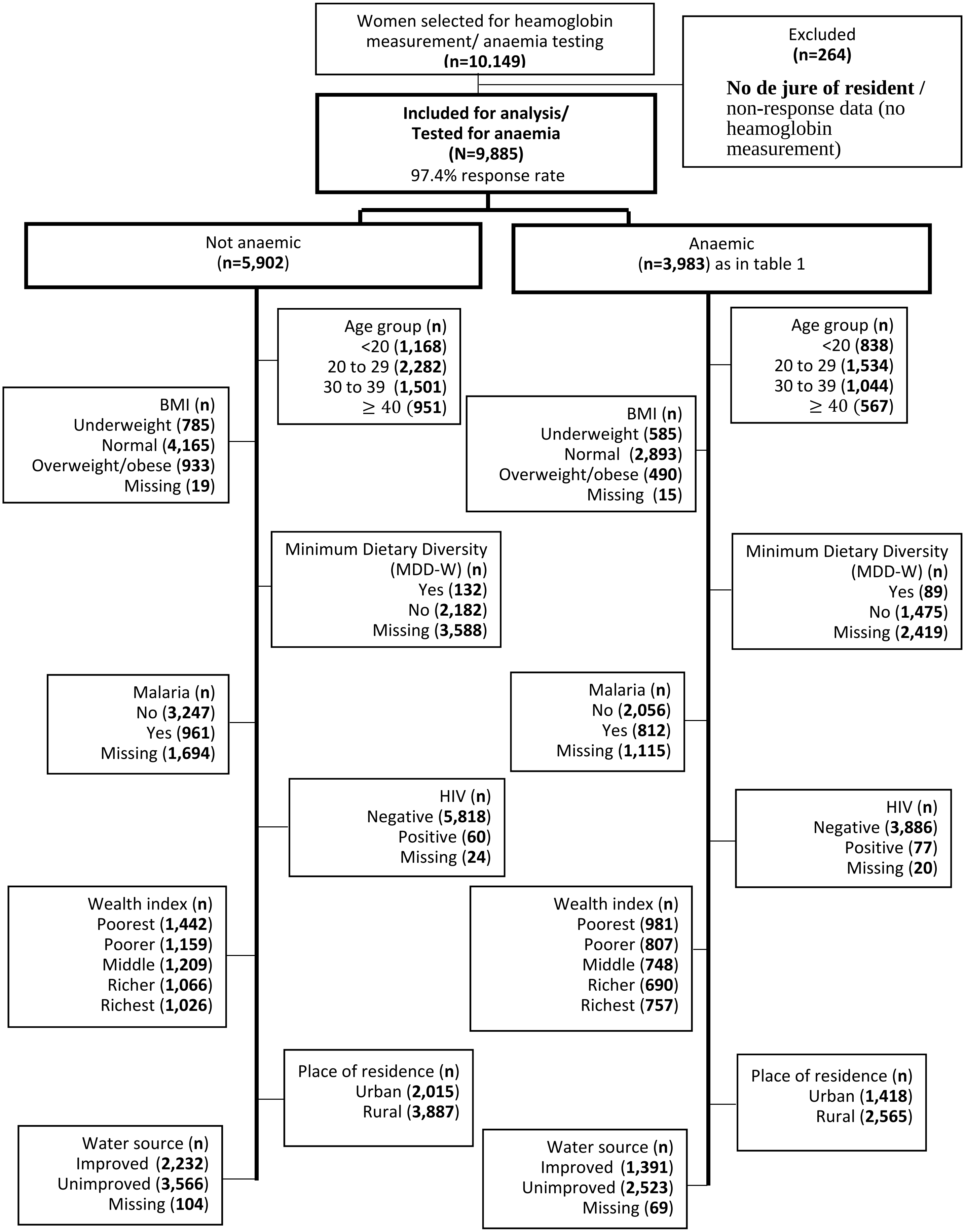

Table 1. Percentage of anaemia by potential explanatory factors in women in DRC

Variables	n	Weighted Percentages (%)	P-value[1]
Anaemia			
No	5,902	61.8	
Yes	3,983	38.2	
Individual level factors			
Age group			0.108
Less than 20	838	40.3	
20 to 29	1,534	38.4	
30 to 39	1,044	38.5	
40 and over	567	34.5	
BMI			**0.002**
Underweight	585	42.2	
Normal	2,893	38.9	
Overweight/obese	490	32.3	
Minimum Dietary Diversity (MDD-W)			0.985
Yes	89	40.3	
No	1475	40.3	
Currently pregnant			**0.002**
No	3,389	37.4	
Yes	594	44.0	
Currently breastfeeding			0.343
No	2,431	38.8	
Yes	1,552	37.4	
Malaria			**<0.001**
No	2,056	37.6	
Yes	812	45.3	
HIV			**0.001**
Negative	3,886	37.9	
Positive	77	55.1	
Occupation			0.196
Not working	1,056	39.9	
Working in sales	814	39.9	
Working in agriculture	1,844	36.2	
Working in other sectors	269	39.1	
Marital status			0.707
Never in union	891	38.8	
Married	2,011	38.8	
Living with partner	672	37.0	
Widowed or separated	409	36.8	
Education			**0.001**
No education	677	32.6	
Primary	1,609	38.2	
Secondary	1,607	40.8	
Higher	90	34.2	

Variables	n	Weighted Percentages (%)	P-value[1]
Household Level Factors			
Wealth index			0.332
Poorest	981	37.8	
Poorer	807	38.0	
Middle	748	37.4	
Richer	690	35.7	
Richest	757	41.7	
Water source			**0.003**
Improved	1,391	36.6	
Unimproved	2,523	39.5	
Community level factors			
Place of residence			0.104
Urban	1,418	40.7	
Rural	2,565	36.9	
Region			**<0.001**
Kinshasa	387	46.8	
Bandundu	470	37.4	
Bas-Congo	264	54.9	
Equateur	526	35.8	
Kasai-occidental	388	46.2	
Kasai-oriental	527	41.4	
Katanga	508	42.6	
Maniema	218	49.2	
Nord-Kivu	147	20.7	
Orientale	392	36.8	
Sud-Kivu	156	22.3	

[1]Pearson Chi-Square test. All p-values are two-sided; p-values in bold are statistically significant

All percentages are using sample selection weights

Table 2a. Estimated odds ratio (95% CI) of anaemia in women in DRC against individual level risk factors from the univariate and multivariable multilevel logistic regression models (N=9,885)

	Univariate multilevel logistic model	**Multivariable multilevel logistic model (with individual level factors only)**	**Multivariable multilevel logistic model (with individual, household and community levels factors)**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**
Age group			
Less than 20 (Ref)	1.00	1.00	1.00
20 to 29	0.89 (0.76 , 1.03)	0.99 (0.49 , 2.01)	0.95 (0.47 , 1.93)
30 to 39	0.91 (0.77 , 1.07)	0.97 (0.45 , 2.09)	0.94 (0.44 , 2.02)
40 and over	**0.72 (0.60 , 0.87)**	0.67 (0.24 , 1.92)	0.64 (0.22 , 1.81)
BMI			
Underweight (Ref)	1.00	1.00	1.00
Normal	0.94 (0.79 , 1.11)	0.69 (0.39 , 1.23)	0.81 (0.45 , 1.44)
Overweight or obese	**0.65 (0.52 , 0.81)**	**0.32 (0.14 , 0.74)**	0.47 (0.20, 1.08)
Minimum dietary diversity (MDD-W)			
Yes (Ref)	1.00	1.00	1.00
No	1.15 (0.40 , 1.91)	1.04 (0.46 , 2.36)	0.77 (0.33 , 1.77)
Currently pregnant			
No (Ref)	1.00	1.00	1.00
Yes	**1.49 (1.26 , 1.76)**	2.24 (0.93 , 5.41)	2.28 (0.94 , 5.53)
Currently breastfeeding			
No (Ref)	1.00	1.00	1.00
Yes	0.97 (0.86 , 1.09)	0.79 (0.36 , 1.7)	0.84 (0.39 , 1.81)
Malaria			
No (Ref)	1.00	1.00	1.00
Yes	**1.33 (1.11 , 1.59)**	**1.91 (1.2 , 3.03)**	**1.66 (1.04 , 2.65)**
HIV			
Negative (Ref)	1.00	1.00	1.00
Positive	**2.19 (1.37 , 3.49)**	**13.45 (1.62, 111.44)**	**18.6 (2.17 , 159.46)**
Infection (HIV & Malaria interaction)			
No	NA	1.00	1.00
Yes		**7.09 (1.20 , 25.10)**	**8.09 (1.31 , 27.10)**
Occupation			
Not working (Ref)	1.00	1.00	1.00
Working in sales	0.94 (0.79 , 1.12)	1.34 (0.69 , 2.61)	1.40 (0.72 , 2.71)
working in agriculture	0.90 (0.77 , 1.05)	0.99 (0.55 , 1.78)	1.03 (0.56 , 1.89)
Working other	0.85 (0.67 , 1.08)	1.81 (0.70 , 4.73)	1.77 (0.68 , 4.62)
Marital status			
Never in union(Ref)	1.00	1.00	1.00
Married	1.03 (0.9 , 1.19)	1.08 (0.45 , 2.6)	1.10 (0.45 , 2.7)

Living with partner	0.96 (0.8 , 1.16)	0.91 (0.36 , 2.31)	1.07 (0.42 , 2.75)
Widowed or separated	0.97 (0.79 , 1.2)	0.98 (0.34 , 2.84)	1.01 (0.35 , 2.92)
Education			
No education(Ref)	1.00	1.00	1.00
Primary	1.15 (0.97 , 1.36)	1.70 (0.98 , 2.95)	1.52 (0.87 , 2.66)
Secondary	1.17 (0.98 , 1.40)	1.64 (0.88 , 3.02)	1.28 (0.67 , 2.45)
Higher	0.82 (0.55 , 1.21)	1.23 (0.14 , 10.83)	0.49 (0.05 , 4.91)
Random effect parameters			
Community level variance component (95% CI)	**-**	**1.62 (1.25 , 2.11)**	**1.40 (1.03 , 1.90)**
Household level variance component (95% CI)	**-**	**4.07 (3.51 , 4.73)**	**4.01 (3.46 , 4.65)**
Intra-class correlation			
Intra-cluster (community) correlation coefficient (95% CI)	**-**	**0.12 (0.08 , 0.17)**	**0.09 (0.06 , 0.15)**
Intra-household correlation coefficient (95% CI)	**-**	**0.85 (0.81 , 0.89)**	**0.85 (0.80 , 0.88)**

Figures in bold mean statistically significant, CI= Confidence Intervals

Table 2b. Estimated odds ratio (95% CI) of anaemia in women in DRC against household level risk factors from the univariate and multivariable multilevel logistic regression models (N=9,885)

	Univariate multilevel logistic model	**Multivariable multilevel logistic model (Household level factors only)**	**Multivariable multilevel logistic model (With individual, household and community levels factors)**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**
Wealth index			
Poorest(Ref)	1.00	1.00	1.00
Poorer	1.08 (0.90 , 1.30)	1.07 (0.84 , 1.35)	1.28 (0.70 , 2.35)
Middle	0.91 (0.76 , 1.10)	0.96 (0.75 , 1.23)	1.06 (0.56 , 2.02)
Richer	0.98 (0.79 , 1.21)	1.03 (0.78 , 1.35)	0.88 (0.40 , 1.92)
Richest	1.12 (0.87 , 1.44)	**1.51 (1.06 , 2.14)**	1.63 (0.50 , 5.36)
Type of source of drinking water			
Improved (Ref)	1.00	1.00	1.00
Unimproved	1.17 (0.99 , 1.38)	**1.26 (1.05 , 1.51)**	1.32 (0.73 , 2.37)
Random effect parameters			
Community level variance component (95% CI)	**-**	**0.78 (0.69 , 0.89)**	**1.40 (1.03 , 1.90)**
Household level variance component (95% CI)	**-**	**1.36 (1.21 , 1.54)**	**4.01 (3.46 , 4.65)**
Intra-class correlation			
Intra-cluster (community) correlation coefficient (95% CI)	**-**	**0.11 (0.09 , 0.13)**	**0.09 (0.06 , 0.15)**
Intra-household correlation coefficient (95% CI)	**-**	**0.43 (0.38 , 0.48)**	**0.85 (0.80 , 0.88)**

Figures in bold mean statistically significant, CI= Confidence Intervals

Table 2c. Estimated odds ratio (95% CI) of anaemia in women in DRC against community level risk factors from the univariate and multivariable multilevel logistic regression models (N=9,885)

	Univariate multilevel logistic model	**Multivariable multilevel logistic model (with community level factors only**	**Multivariable multilevel logistic model (With individual, household and community levels factors)**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**
Place of residence			
Urban (Ref)	1.00	1.00	1.00
Rural	0.91 (0.75 , 1.10)	0.95 (0.73 , 1.22)	0.98 (0.47 , 2.05)
Region			
Kinshasa (Ref)	1.00	1.00	1.00
Bandundu	**0.58 (0.40 , 0.84)**	**0.45 (0.26 , 0.77)**	0.41 (0.09 , 1.87)
Bas-Congo	**1.60 (1.00 , 2.53)**	1.56 (0.81 , 2.91)	2.60 (0.47 , 14.26)
Equateur	**0.62 (0.43 , 0.89)**	**0.48 (0.29 , 0.81)**	0.24 (0.05 , 1.06)
Kasai-occidental	1.14 (0.76 , 1.72)	0.83 (0.46 , 1.50)	0.80 (0.17 , 3.89)
Kasai-oriental	1.05 (0.72 , 1.54)	0.79 (0.46 , 1.37)	0.56 (0.13 , 2.55)
Katanga	0.88 (0.60 , 1.28)	0.68 (0.40 , 1.16)	0.59 (0.14 , 2.51)
Maniema	1.14 (0.72 , 1.82)	0.81 (0.42 , 1.55)	0.56 (0.10 , 3.27)
Nord-Kivu	**0.25 (0.16 , 0.40)**	**0.20 (0.10 , 0.37)**	**0.05 (0.01 , 0.31)**
Orientale	**0.55 (0.38 , 0.81)**	**0.42 (0.24 , 0.74)**	**0.15 (0.03 , 0.69)**
Sud-Kivu	**0.37 (0.23 , 0.58)**	**0.33 (0.17 , 0.63)**	**0.13 (0.02 , 0.72)**
Random effect parameters			
Community level variance component (95% CI)	**-**	**0.65 (0.56 , 0.75)**	**1.40 (1.03 , 1.90)**
Household level variance component (95% CI)	**-**	**1.33 (1.18 , 1.50)**	**4.01 (3.46 , 4.65)**
Intra-class correlation			
Intra-cluster (community) correlation coefficient (95% CI)	**-**	**0.08 (0.06 , 0.10)**	**0.09 (0.06 , 0.15)**
Intra-household correlation coefficient (95% CI)	**-**	**0.40 (0.35 , 0.45)**	**0.85 (0.80 , 0.88**

Figures in bold mean statistically significant, CI= Confidence Intervals