0[1]Article

Anaemia in Preschool aged children in the DR. Congo: Finding from a Nationally Representative Survey

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Abstract: Anaemia is the most prevalent nutritional deficiency in the World and is associated with long-lasting developmental effects in children. Anaemia weakens the immune system and impairs cognitive development of children. Anaemia is multifactorial; therefore, anaemia's preventive/control measures should be evidence-based**.** This paper aimed to investigate the prevalence and correlates of anaemia in preschool aged children at individual, maternal/household and community level in the Democratic Republic of Congo (DRC). Retrospective, nationally representative cross-sectional data, the 2013-2014 DRC Demographic and Health Survey (DHS) was used. Three -levels random intercept logistics regression models were fitted to the data using the outcome anaemia in children, defined as a haemoglobin concentration below 11dl with potential risk factors grouped at individual, maternal/household and community levels. Anaemia in children is a severe public health issue in the DRC, 63% of school aged children are anaemic. Anaemia is highly prevalent amongst males, children with infections (fever/malaria and intestinal parasites), whose mothers are anaemic, from poorest household, and whose drinking source of water is unclean, and who reside in provinces with recent/previous armed forces attacks. Results from this paper highlight the need for a clean and safe environment for children's growth.

1. Introduction

Anaemia, a condition in which there is a reduced haemoglobin concentration is a serious worldwide public health problem. Recent evidence suggests that 30% of the world population is anaemic[1]. Children aged between 0 and 5 years and women of reproductive age are the most affected. The latest World Health Organisation anaemia estimates suggest a global prevalence of 42% in children aged between 0 to 5 years, and 30% in women, and 60% in children aged between 0 to 5 years in Africa[1]. Anaemia in children is defined as a haemoglobin concentration of <11dl at sea level[2].
Anaemia weakens the person's immune system exposing the individual to infections. In children anaemia is associated with long-lasting developmental effects[3]. Even at its mild stage anaemia can impair cognitive development of children.

Anaemia is multifactorial and remains the most prevalent nutritional deficiency in the world[3]. Iron deficiency anaemia is the most prevalent cause of anaemia [4]. Immediate causes of anaemia include malaria, intestinal parasites/hookworm, HIV, and insufficient dietary intake. The mechanism through which some of these factors are linked to anaemia is well documented[5]. Other factors associated with anaemia include environmental, community and household, and socio-demographic factors such as maternal education, and household sanitation.

In this paper we describe the prevalence of anaemia in children aged between 0 to 5 years in the Democratic Republic of Congo (DR Congo) and study multifaced contributing factors of anaemia using country level representative data, and hence can guide nutritional and anaemia control/prevention measures.

2. Data and Methods

Data

Nationally representative data, the Democratic Republic of Congo 2013-2014 Demographic and Health Survey (DRC-DHS) was used[4, 6]. The DRC-DHS is hierarchical probabilistic sample including stratum/district, clusters/ villages, communities, household, maternal and children level information. DHS groups households that participate in the survey into clusters/villages and cluster coordinates are collected using GPS receivers [6]. This study is a complete case analysis focusing on children tested for anaemia as described in Fig 1. The DRC-DHS data was further linked to the DRC Geographical data to map the prevalence of anaemia by provinces (Fig 2).

Outcome and other covariates

The outcome variable is anaemia in children defined as reduced blood haemoglobin concentration below of 11 dl. Potential correlates of anaemia (as listed in Table 1) are grouped and included as individual, maternal, household and community level factors. Potential individual factors included age, sex, intestinal parasites, birthweight and Minimum Dietary Diversity (MDD). MDD was derived as recommended by Food and Nutrition Technical Assistance (FANTA) using children's food intake in the last 7 days[7]. Whether the mother is anaemic, had intestinal parasites, took iron tablets during pregnancy, maternal education are maternal factors.

Household factors included household wealth status, the source of drinking water as previously described [4]. The province and place of residence are included as community level factors.

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

Children selected for heamoglobin measurement/ anaemia testing **(n=10,508)**

Included for analysis/Tested for anaemia (N=10,508), 100% response rate

Not anaemic (**37.5%**)
(**n=3,940**)

Anaemic (**62.5%**)
(**n=6,568**) as in table 1

Sex (n)
Male (1,838)
Female (2,102)

Age (n)
< 1 year (301)
1 year (813)
2 years (929)
3 years (945)
4 years (952)

Sex (n)
Male (3,368)
Female (3,200)

Age (n)
< 1 year (828)
1 year (1668)
2 years (1465)
3 years (1480)
4 years (1127)

Low birthweight (n)
No (3655)
Yes (285)

Breastfed (n)
No (1603)
Yes (2337)

Low birthweight (n)
No (6068)
Yes (500)

Breastfed (n)
No (2353)
Yes (4215)

Intestinal parasites (n)
NO (1450)
Yes (2449)

Intestinal parasites (n)
No (2907)
Yes (3617)
Missing (44))

Minimum Dietary Diversity (MDD) (n)
No (2110)
Yes (164)
Missing (1666)

Minimum Dietary Diversity (MDD) (n)
No (3936)
Yes (313)
Missing

Fever (n)
No (2870)
Yes (1056)
Missing (14)

Fever ()
No (2870)
Yes (1056)
Missing (14)

Fever (n)
No (4023)
Yes (2528)
Missing (17)

Fever ()
No (2870)
Yes (1056)
Missing (14)

Maternal education (n)
No education (824)
Primary (1601)
Secondary or higher (1515)

Maternal education (n)
No education (1367)
Primary (2927)
Secondary or higher (2274)

Mother is anaemic (n)
No (2599)
Yes (1297)

Mother is anaemic (n)
No (3522)
Yes (2976)
Missing (70)

Mother given or bought iron during pregnancy (n)
No (937)
Yes (1423)
Missing (1580)

Mother given or bought iron during pregnancy (n)
No (1947)
Yes (2248)
Missing (2373)

Figure 1. Continue…

Not anaemic (**37.5%**)
(**n=3,940**)

Anaemic (**62.5%**)
(**n=6,568**) as in table 1

Mother given drugs for intestinal parasites during pregnancy (n)
No (1006)
Yes (1350)
Missing (1584))

Mother given drugs for intestinal parasites during pregnancy (n)
No (2051)
Yes (2131)
Missing (2386)

Wealth index (n)
Poorest (835)
Poorer (853)
Middle (813)
Richer (718)
Richest (721)

Wealth index (n)
Poorest (1798)
Poorer (1486)
Middle (1366)
Richer (1104)
Richest (814)

Water source (n)
Improved (1499)
Unimproved (2399)
Missing (42)

Water source (n)
Improved (2013)
Unimproved (4481)
Missing (74)

Place of residence (n)
Urban (1331)
Rural (2609)

Place of residence (n)
Urban (1951)
Rural (4617)

Province (n)
Kinshasa (296)
Kwango (243)
Kwilu (279)
Mai-ndombe (135)
Kongo central (147)
Equateur (105)
Mongala (154)
Nord-ubangi (99)
Sud-ubangi (171)
Tshuapa (96)
Kasai (133)
Kasai-central (86)
Kasai-oriental (90)
Lomami (88)
Sankuru (106)
Haut-katanga (142)
Haut-lomami (157)
Lualaba (98)
Tanganyka (97)
Maniema (122)
Nord-kivu (418)
Bas-uele (81)
Haut-uele (72)
Ituri (95)
Tshopo (109)
Sud-kivu (321)

Province (n)
Kinshasa (377)
Kwango (269)
Kwilu (267)
Mai-ndombe (295)
Kongo central (362)
Equateur (185)
Mongala (211)
Nord-ubangi (207)
Sud-ubangi (201)
Tshuapa (175)
Kasai (331)
Kasai-central (366)
Kasai-oriental (287)
Lomami (410)
Sankuru (213)
Haut-katanga (155)
Haut-lomami (243)
Lualaba (154)
Tanganyka (292)
Maniema (391)
Nord-kivu (217)
Bas-uele (164)
Haut-uele (149)
Ituri (171)
Tshopo (219)
Sud-kivu (257)

Statistical analysis

Descriptive analysis, the univariable included numbers and proportions for categorical variables and mean/SD for continuous variables. Pearson Chi-square test was used to assess independently the association between anaemia and each potential predictor after applying survey weight.

Random effects, multilevel logistic regression models were fitted to the data as univariable and as multivariable models. Variance components were computed at household and community levels. The analysis was carried out using SAS software [8]. R Studio was used with geographical data to produce maps as depicted in Fig 2.

3. Results

Exploratory results using Pearson Chi-square

Sixty percent of children aged between 0 to 5 years old are anaemic in the DRC. With reference to the WHO categorisation, these results suggest that anaemia in children in the DRC is a severe public health problem. Potential factors associated with anaemia in children are the child's age, breastfeeding, infection including fever and intestinal parasites, maternal anaemic status, whether the mother was given drugs for intestinal parasites, mother was given or bought iron during pregnancy, household wealth index, the source of drinking water, and province, Table 1 and Figure 2.

Table 1 Percentages of anaemia by potential explanatory factors in children in the DRC

Variables	n	**Weighted** percentages **(%)**	**p-value**
Anaemia			
No	3,940	40.5	
Yes	6,568	59.5	
Individual level factors			
Sex			0.288
Male	3,368	60.9	
Female	3,200	58.2	
Age in years			**<0.001**
< 1 year	828	70.4	
1 year	1,668	67.1	
2 years	1,465	57.4	
3 years	1,480	57.3	
4 years	1,127	50.0	
Low birthweight			0.519
No	6,068	59.3	
Yes	500	61.7	
Breastfed			**0.004**
No	2,353	56.0	
Yes	4,215	61.7	
Infection			
Fever			**<0.001**
No	4,023	55.1	
Yes	2,528	68.9	
Intestinal parasites			**0.002**
No	2,907	63.4	
Yes	3,617	57.3	
Minimum Dietary Diversity (MDD)			0.370
No	3,936	63.3	
Yes	313	66.5	
Maternal factors			
Maternal education			0.212
No education	1367	55.8	
Primary	2927	61.3	
Secondary or higher	2274	59.4	

Sample selection weight was applied in all percentages.

[a] Pearson Chi-Square test. All p-values are to-sided; p-value in bold are statistically significant.

Table 1 continue

Variable	n	Weighted percentages (%)	P-value[a]
Maternal health indicator			
Mother is anaemic			**<0.001**
No	3,522	54.1	
Yes	2,976	67.9	
Mother given drugs for intestinal parasites during pregnancy			**0.023**
No	2,051	65.3	
Yes	2,131	58.2	
Mother given or bought iron during pregnancy			**<0.001**
No	1,947	64.1	
Yes	2,248	59.4	
Household level factors			
Wealth index			**0.015**
Poorest	1,798	67.2	
Poorer	1,486	58.2	
Middle	1,366	61.6	
Richer	1,104	54.7	
Richest	814	55.0	
Water source			**0.001**
Improved	2,013	53.5	
Unimproved	4,481	63.6	
Community level factors			
Place of residence			0.825
Urban	1,951	59.1	
Rural	4,617	59.7	
Province (as presented in Figure 2**)**			**<0.001**

Sample selection weight was applied in all percentages.

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

Fig 2. Cases of anemia / number of children (0-59 months)

Prevalence of anemia (%)
- [32,56.3)
- [56.3,64)
- [64,72)
- [72,81]
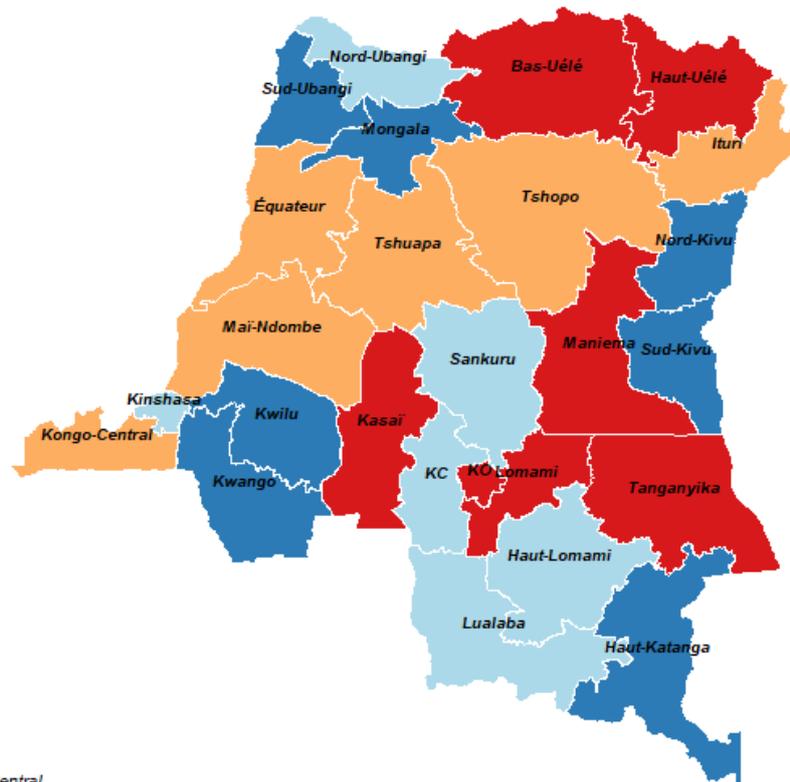
KO: Kassai Occidental, KC: Kassai Central
@NilKandala.port.ac.uk, Nov 2022

By region, anaemia prevalence significantly varies by region. Anaemia is more prevalent in Kasai, Lomami, Tanganyika and in the Uele provinces (figure 2).

Since these results did not consider other observed factors and the unobserved factors, further analysis was carried as presented below.

The univariate analysis results

Results suggest that, independently using univariate multilevel random effect models, at individual level anaemia in children is significantly associated with the child's age, sex, breastfeeding, and infections (fever and intestinal parasites). Whether the mother is anaemic is the only maternal factor related to anaemia in children in the DRC. Wealth index and the type of drinking water are household level factors associated with anaemia in children. The place of residence and the province are community factors related with anaemia in children in the DRC. However, low birth weight, the Minimum Dietary Diversity (MDD), maternal education, whether the mother had intestinal parasites or had iron tablets during pregnancy are not statistically associated with anaemia in children in the DRC, see Tables 2.a, 2.b 2.c & 2.d.

Results from multivariable tree-level random intercept models

Different multivariable multilevel random intercept models were fitted with individual, maternal, household and community factors separately. The models suggest that factors associated with anaemia in children at individual level include the age and sex, low birthweight and fever. However, breastfeeding and intestinal parasites that were significantly related with anaemia in children in exploratory analysis and independently in the univariate analysis are not statistically related to anaemia in children. The MDD remained statistically unrelated to anaemia in children.

Again, whether the mother is anaemic is the only maternal factor associated with anaemia in children while other maternal factors including education, whether the mother had drugs for intestinal parasites or iron tables remained statistically insignificant.

Household wealth index is the only household factor significantly related with anaemia in children, but the type of drinking water that was associated with anaemia in children independently and in the exploratory analysis is not anymore statistically related to anaemia after accounting for the effect of household wealth.
The place of residence and the province are again community related factors statistically associated with anaemia in children, Table 2.a, 2.b, 2c & 2d.

Multivariable tree-level random intercept model with all level factors

A further model was fitted to the data combining all factors, individual, maternal, household and community factors. The results suggest that after accounting for the effects of other observed and unobserved factors sex and age, low birthweight, fever, whether the mother is anaemic, household wealth, place of residence and province are respectively individual, household and community factors associated with anaemia in children in the DRC. However, breastfeeding, intestinal parasites, MDD, maternal education, and whether the mother had iron tablets during pregnancy are not statistically related to anaemia in children after accounting for the effect of other factors, Table 2.a, 2.b, 2c & 2d.

Table 2a. Results from the multilevel analysis of anaemia in children in the DRC against individual level risk factors from the univariate and multivariable multilevel logistic regression models

Variables	Univariate multilevel logistic model OR (95% CI)	Multivariable multilevel logistic model (with individual level factors only) OR (95% CI)	Multivariable multilevel logistic model (with individual, maternal, household and community levels factors) OR (95% CI)
Individual level			
Sex			
Male	1.00	1.00	1.00
Female	**0.66 (0.56 , 0.79)**	**0.67 (0.55 , 0.82)**	**0.65 (0.54 , 0.79)**
Age in years			
< 1 year	1.00	1.00	1.00
1 year	**0.45 (0.32 , 0.63)**	**0.54 (0.39 , 0.74)**	**0.43 (0.3 , 0.61)**
2 years	**0.31 (0.22 , 0.43)**	**0.45 (0.30 , 0.65)**	**0.31 (0.22 , 0.45)**
3 years	**0.30 (0.22 , 0.42)**	**0.39 (0.28 , 0.54)**	**0.33 (0.24 , 0.47)**
4 years	**0.16 (0.11 , 0.22)**	**0.25 (0.18 , 0.35)**	**0.17 (0.12 , 0.25)**
Low birthweight			
No	1.00	1.00	1.00
Yes	1.39 (0.97 , 1.99)	**1.56 (1.04 , 2.32)**	**1.65 (1.13 , 2.41)**
Breastfed			
No	1.00	1.00	1.00
Yes	**1.52 (1.19 , 1.94)**	1.27 (0.82 , 1.97)	1.07 (0.82 , 1.39)
Infection			
Fever			
No	1.00	1.00	1.00
Yes	**2.74 (2.19 , 3.41)**	**2.16 (1.69 , 2.75)**	**2.51 (2 , 3.15)**
Intestinal parasites			
No	1.00	1.00	1.00
Yes	**0.64 (0.51 , 0.81)**	0.82 (0.64 , 1.06)	0.81 (0.22 , 3.01)
Minimum Dietary Diversity (MDD)			
No	1.00	1.00	1.00
Yes	0.88 (0.54 , 1.44)	0.89 (0.53 , 1.48)	0.27 (0.03 , 2.49)
Random effect parameters			
Community level variance component (95% CI)	-	**1.51 (1.31 , 1.75)**	**1.77 (1.56 , 2.00)**
Household level variance component (95% CI)	-	**2.45 (2.24 , 2.69)**	**3.15 (2.94 , 3.38)**
Intra-class correlation			
Intra-cluster (community) correlation coefficient (95% CI)	-		**0.12 (0.09 , 0.15)**
Intra-household correlation coefficient (95% CI)	-		**0.78 (0.76 , 0.80)**

Figure in bold indicate statistical significance at 5% significant level

Table 2b. Results from the multilevel analysis of anaemia in children in the DRC against maternal level risk factors from the univariate and multivariable multilevel logistic regression models

Variables Maternal factors	Univariate multi-level logistic model OR (95% CI)	Multivariable multilevel logistic model (with maternal factors only) OR (95% CI)	Multivariable multi-level logistic model (with individual, maternal, household and community levels factors) OR (95% CI)
Maternal education			
No education	1.00	1.00	1.00
Primary	0.92 (0.66, 1.28)	0.63 (0.23, 1.73)	1.31 (0.21, 7.99)
Secondary or higher	0.72 (0.5, 1.04)	0.68 (0.23, 2.03)	1.27 (0.17, 9.52)
Maternal health indicator			
Mother is anaemic			
No	1.00	1.00	1.00
Yes	**2.3 (1.79, 2.95)**	**2.56 (1.25, 5.24)**	**2.39 (1.84, 3.09)**
Mother given drugs for intestinal parasites during pregnancy			
No	1.00	1.00	1.00
Yes	0.79 (0.40, 1.59)	0.79 (0.37, 1.72)	1.01 (0.28, 3.65)
Mother given or bought iron during pregnancy			
No	1.00	1.00	1.00
Yes	0.91 (0.45, 1.85)	1.06 (0.48, 2.31)	0.64 (0.17, 2.46)
Random effect parameters			
Community level variance component (95% CI)	-	**2.20 (0.69, 7.06)**	**1.77 (1.56, 2.00)**
Household level variance component (95% CI)	-	**73.80 (62.83, 86.68)**	**3.15 (2.94, 3.38)**

Figures in bold are statistically significant at 5% significance level

Table 2c. Results from the multilevel analysis of anaemia in children in the DRC against house-hold level risk factors from the univariate and multivariable multilevel logistic regression models

Household level factors	Univariate multilevel logistic model OR (95% CI)	Multivariable multilevel logistic model (with household level factors only) OR (95% CI)	Multivariable multilevel logistic model (with individual, maternal, household and community levels factors) OR (95% CI)
Wealth index			
Poorest	1.00	1.00	1.00
Poorer	**0.64 (0.44, 0.93)**	**0.66 (0.46, 0.96)**	**0.67 (0.46, 0.98)**
Middle	**0.52 (0.35, 0.77)**	**0.53 (0.36, 0.79)**	**0.55 (0.36, 0.82)**
Richer	**0.43 (0.28, 0.67)**	**0.46 (0.29, 0.73)**	**0.45 (0.28, 0.74)**
Richest	**0.20 (0.12, 0.36)**	**0.21 (0.12, 0.39)**	**0.19 (0.10, 0.40)**
Water source			
Improved	1.00	1.00	1.00
Unimproved	**1.72 (1.21, 2.45)**	1.17 (0.80, 1.72)	**1.31 (0.90, 1.9)**
Random effect parameters			
Community level variance component (95% CI)	-	**1.88 (1.67, 2.10)**	**1.77 (1.56, 2.00)**
Household level variance component (95% CI)	-	**3.13 (2.92, 3.35)**	**3.15 (2.94, 3.38)**

Figures in bold are statistically significant at 5% significance level

Table 2d. Results from the multilevel analysis of anaemia in children in the DRC against community level risk factors from the univariate and multivariable multilevel logistic regression models

Community level factors	Univariate multi-level logistic model OR (95% CI)	Multivariable multi-level logistic model (with community level factors only) OR (95% CI)	Multivariable multilevel logistic model (with individual, maternal, household and community level factors) OR (95% CI)
Place of residence			
Urban	1.00	1.00	1.00
Rural	**1.72 (1.10, 2.68)**	**1.73 (1.14, 2.61)**	**1.67 (1.08, 2.58)**
Province			
Kinshasa	1.00	1.00	1.00
Kwango	0.71 (0.26, 1.97)	0.45 (0.15, 1.3)	0.38 (0.12, 1.14)
Kwilu	0.56 (0.21, 1.51)	0.38 (0.13, 1.05)	**0.33 (0.11, 0.94)**
Mai-ndombe	**4.25 (1.42, 12.72)**	2.84 (0.92, 8.8)	2.41 (0.76, 7.59)
Kongo central	**5.38 (1.96, 14.8)**	**3.53 (1.23, 10.12)**	**3.23 (1.1, 9.47)**
Equateur	2.15 (0.67, 6.88)	1.44 (0.44, 4.75)	1.01 (0.3, 3.45)
Mongala	1.19 (0.38, 3.71)	0.74 (0.23, 2.42)	0.57 (0.17, 1.93)
Nord-ubangi	**3.38 (1.05, 10.91)**	2.25 (0.68, 7.51)	1.83 (0.54, 6.23)
Sud-ubangi	0.87 (0.28, 2.69)	0.56 (0.17, 1.81)	0.44 (0.13, 1.47)
Tshuapa	2.69 (0.81, 8.93)	1.65 (0.48, 5.76)	1.18 (0.33, 4.26)
Kasai	**5.13 (1.78, 14.77)**	**3.29 (1.09, 9.9)**	2.67 (0.85, 8.36)
Kasai-central	**15.89 (5.27, 47.9)**	**11.02 (3.57, 34.08)**	**7.72 (2.43, 24.48)**
Kasai-oriental	**10.48 (3.4, 32.25)**	**8.44 (2.72, 26.16)**	**6.45 (2.03, 20.5)**
Lomami	**19.88 (6.75, 58.56)**	**13.66 (4.51, 41.41)**	**9.49 (3.05, 29.49)**
Sankuru	**3.50(1.10, 11.09)**	2.13 (0.64, 7.10)	1.51 (0.44, 5.23)
Haut-katanga	0.70 (0.22, 2.19)	0.57 (0.18, 1.79)	0.49 (0.15, 1.58)
Haut-lomami	1.48 (0.48, 4.56)	0.96 (0.30, 3.08)	0.71 (0.22, 2.36)
Lualaba	1.65 (0.49, 5.49)	1.12 (0.33, 3.84)	0.83 (0.23, 2.92)
Tanganyka	**10.21 (3.13, 33.3)**	**6.43 (1.89, 21.88)**	**4.15 (1.19, 14.5)**
Maniema	**8.07 (2.9, 22.46)**	**5.61 (1.96, 16.08)**	**4.87 (1.66, 14.24)**
Nord-kivu	**0.12 (0.05, 0.32)**	**0.09 (0.03, 0.23)**	0.08 (0.03, 0.21)
Bas-uele	3.00 (0.86, 10.5)	1.94 (0.54, 7.03)	1.41 (0.37, 5.3)
Haut-uele	**4.4 (1.25, 15.51)**	2.83 (0.78, 10.34)	2.37 (0.63, 8.86)
Ituri	2.77 (0.87, 8.83)	1.69 (0.50, 5.66)	1.67 (0.49, 5.71)
Tshopo	**3.63 (1.13, 11.62)**	2.45 (0.74, 8.09)	1.94 (0.57, 6.58)
Sud-kivu	**0.32 (0.12, 0.84)**	**0.20 (0.07, 0.56)**	**0.16 (0.06, 0.44)**
Random effect parameters			
Community level variance component (95% CI)	-	**1.30 (1.12, 1.52)**	**1.77 (1.56, 2.00)**
Household level variance component (95% CI)	-	**3.11 (2.91, 3.33)**	**3.15 (2.94, 3.38)**

Figures in bold are statistically significant at 5% significance level

Sex & age

Anaemia in children in the DRC differs significantly by sex and age. Females are about 30% times less likely to have anaemia compared to their male counterpart. By age, anaemia significantly decreases with an increased age. These results are regardless of whether the model is fitted with sex/age variables alone or when accounting for the effect of other factors (observed and unobserved), Table 2.a & Figure 3 & 4.
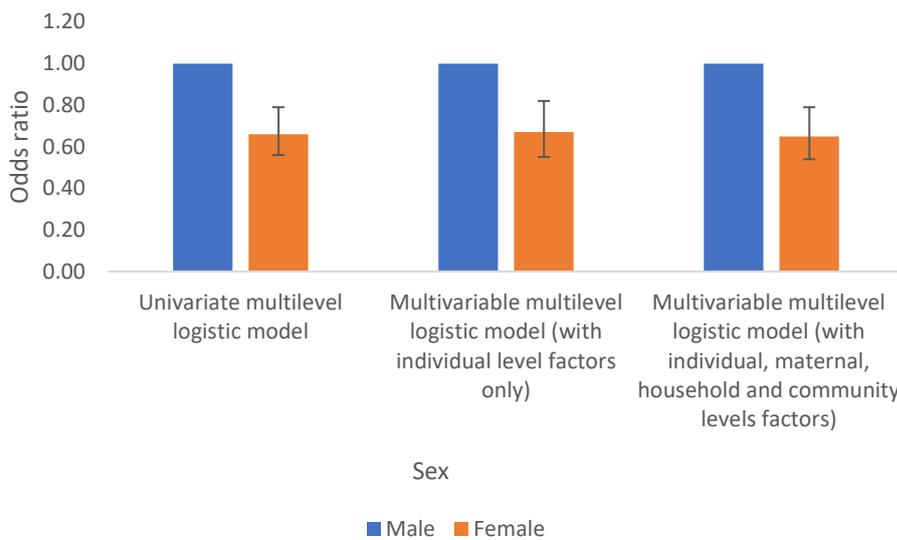

Figure 3. Odds ratio of anaemia in children by sex, error bars are 95% CI with male as the reference category
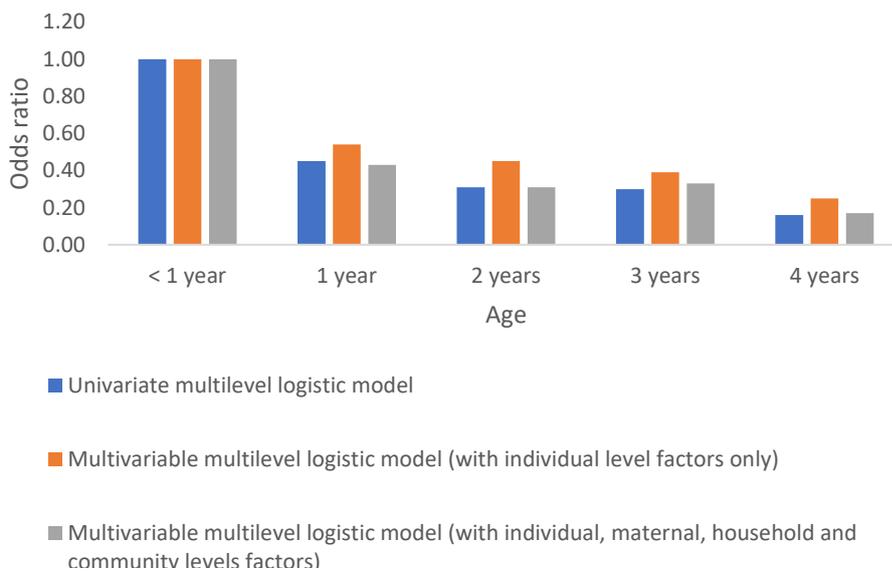
Figure 4. Odds ratio of anaemia in children by age, < 1year as the reference category

Infection (fever as malaria proxy)

Fever is another significant factor related to anaemia in children in the DRC. Children who had fever (a proxy for malaria) are associated with a two fold increase in odds of anaemia compared to those children who had not fever and these results are similar even after accounting for the effects of observed and unobserved factors, Table 2.a and Figure 5.
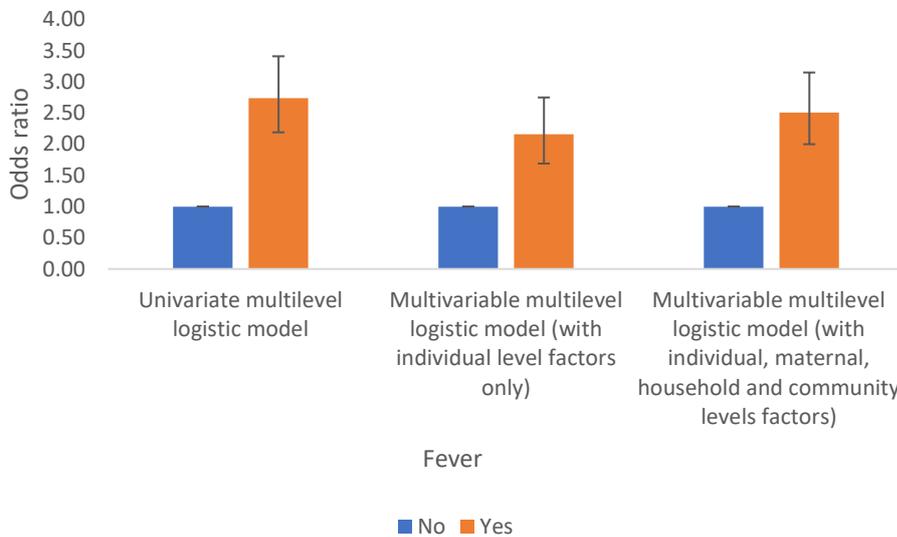
Figure 5. Odds ratio of anaemia in children whether they had fever, no fever is the reference category

Minimum Dietary Diversity (MDD)

Results suggest that children who had their minimum dietary diversified are less likely to have anaemia than their counterparts who did not and this is consistent for all models. However, these results are not statistically significant. Table 2.a and Figure 6.
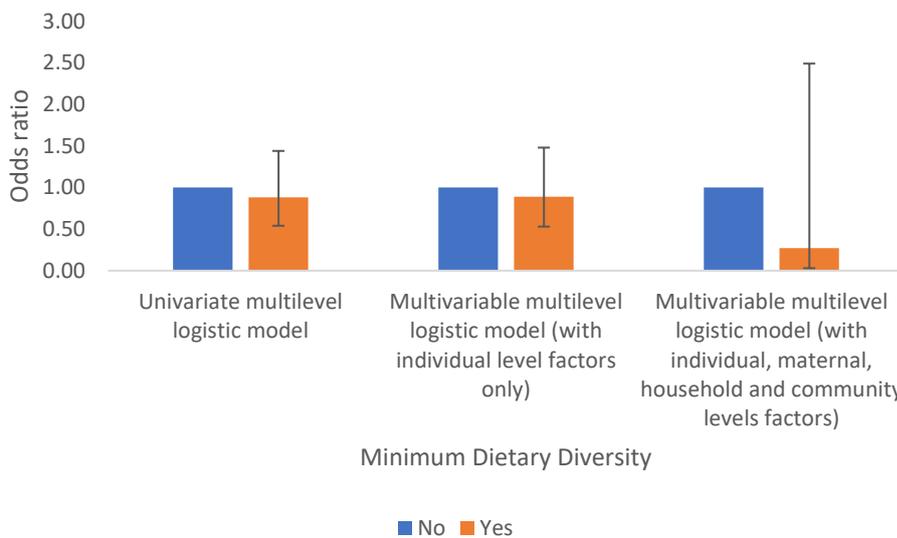
Figure 6. Odds ratio of anaemia in children by MDD category, no MDD as the reference category

Maternal health indicator (whether the mother is anaemic)

Maternal anaemia is another important determinant of anaemia in children in the DRC. Children whose mothers are anaemic have two folds increase odds of anaemia compared to those whose mothers are not anaemic and the results remain significant even after controlling for the effects of other factors (observed or unobserved), Table 2.b and Figure 7.
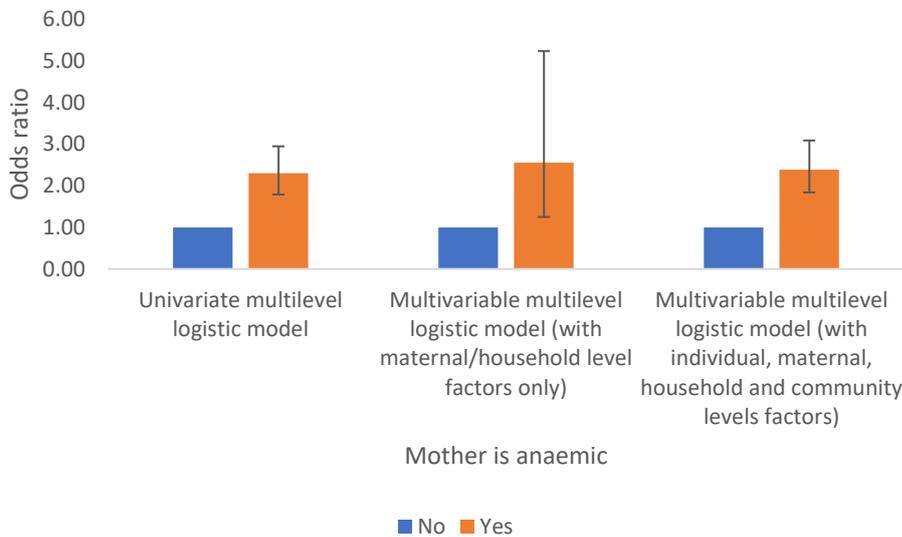
Figure 7. Odds ratio of anaemia in children by maternal anaemia, maternal not anaemic as the reference category

Household Wealth Index

Anaemia in children in the DRC varies significantly by household wealth. The odds of anaemia decrease with an increase household wealth and this decline is observed whether independently or after accounting for the effects of other factors, Table 2.c and Figure 8.
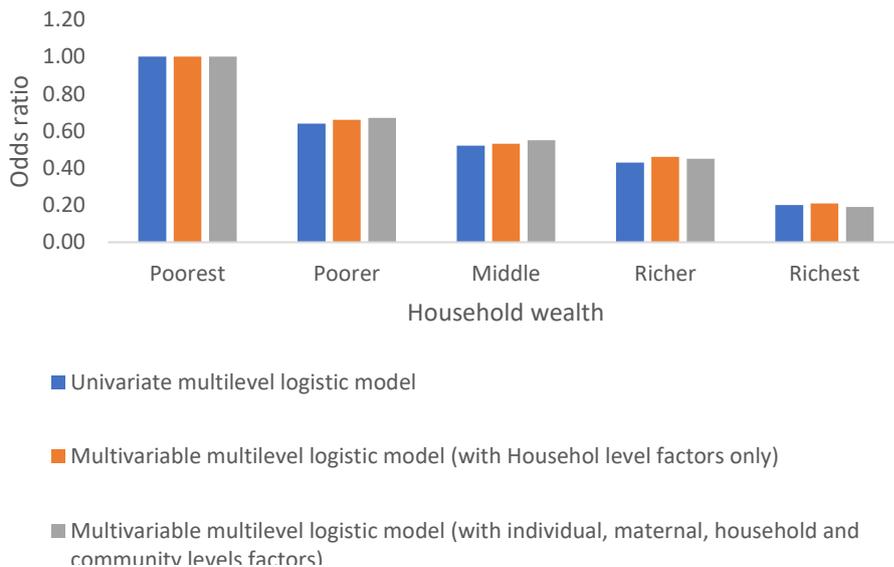
Figure 8. Odds ratio of anaemia in children by household wealth, poorest as the reference category

Child health and poverty

Interaction term was included between intestinal parasites and household wealth and results suggest that those children from poor/poorest household are associated with a 3-fold increase of hookworm infection.

Community factors (the place of residence and province)

Children living in rural area are associated with almost 70% increased odds of anaemia compared to those living in some urban areas. However, children living from the capital city, Kinshasa are more likely to have anaemia than their counterpart living in any other provinces, Table 2.d. Anaemia in children is higher in provinces with frequent armed conflicts including Kasai, Lomamy, Tanganiyka, Maniema, Mai-Ndombe, and Kongo Central, Table 2.d.

Random effects

The analysis indicates significant random variations at household and community level, with significant higher variations within households in the DRC.

4. Discussion

This is a retrospective cross-sectional study using representative country level data to describe and explore the prevalence and risk factors of anaemia in pre-school aged children from the DRC. Three levels random effect logistic regression models were used to explore risk factors at individual, household and community levels and quantify the effect of unobserved anaemia contributing factors. Sixty three percent of children in the DRC are anaemic. According to the WHO threshold anaemia in children in the DRC is a severe public health concern [9] and it is higher than the estimated global anaemia prevalence in children less than 5 years of age of 42% and also higher than Africa's region average prevalence of 60%. Male children, younger age, low birthweight, fever, intestinal parasites are individual level factors significantly associated with anaemia; maternal anaemia is the only maternal factor associated with anaemia in children. Poor household wealth, and unimproved type of source of drinking water are household level factors related to anaemia, urban residence and province are community risk factors associated with anaemia in children in the DRC. MDD and maternal education are not statistically associated with anaemia in children in the DCR. Anaemia prevalence in children in DRC varies significantly within and between households as well within communities.

Sex
Higher odds of anaemia related with male sex is not surprising; previous studies have suggested similar results. It is argued that it could be inherited (genetic) [10] or acquired (environmental factors) and might be due to X-linked sideroblastic anaemia and occur most commonly in males. Sideroblastic anaemia are anaemias in which ring sideroblastic are present on the bonne marrow aspirate smear stained for iron [10, 11].

Minimum Dietary Diversity
Anaemia in young children is usually linked to diet, and a delay in introducing iron-fortified foods (ref), food allergies and other feeding difficulties [12, 13]. Although the results suggest that children with a minimum diversity diet are associated with lower odds of anaemia and this remained consistent even when adjusting for other factors, it is statistically insignificant which might be due to a small sample size recorded for MDD.

Low birthweight
Low birthweight is another contributing factor of anaemia in children in the DRC. Low birthweight happens when a baby weights less than 2500g at birth as per the WHO classification [14, 15] . Research suggests that babies born with low birthweight are more likely to have developmental difficulties and health complications than babies born at normal weight and they are more likely to have eating trouble, hence anaemia [16, 17].

Infection (malaria and hookworm/intestinal parasites)
Infection (fever/malaria and intestinal parasites) is another contributing factor of anaemia in children in the DRC. Similar results were found when studying anaemia in their mothers[4]. Malaria infection causes a reduction in haemoglobin concentrations leading to anaemia. Malaria also causes a decreased production of red blood count and destroys red blood cells [18, 19]. This is known as malarial anaemia and its pathological process is well documented [18, 20]. It has been postulated that the prevalence of anaemia in children increases with an increased malaria transmission [21, 22].

Intestinal parasites –Hookworm infection is known as helminth nematode or Necator americanus and ancylostoma duodenale is transmitted through contact with contaminated soil [23]. Hookworm is argued to be amongst the most important tropical diseases in humans, sucking blood, hence anaemia [24]. In DRC and many other developing countries it is socially accepted for children to walk without shoes or play barefoot [25], sometimes on contaminated soils[26-28].

Household wealth status
Anaemia odds increase with a decreased household wealth, suggesting that poor household wealth is directly linked to poor child's health. Household wealth index includes building composition, household assets such as lands, car, bike, electricity, TV and other possessions. There is a body of evidence suggesting that poverty influences health and especially children's development and health outcomes [29], also highlighted in this paper by statistical significant interactions between hookworm infections and household wealth. A systematic review [30] suggests a direct association between income/possessions and child health outcomes while paediatricians have

observed that children from a poor family often have poor nutrition because of poorer family's inability to afford enough healthy food [31-33].

Maternal education

The results suggest non-direct statistical significant association between anaemia and maternal education in the DRC, which is surprising given that the link between child health and maternal education has been well documented [34-37].

The place of residence and province

There are significant geographical disparities in anaemia in children within provinces in the DRC. Population displacement due to armed conflicts (especially with the invasion and the occupation of the DRC by its neighbours Rwanda and Uganda) prevalent in the majority of provinces in the DRC, is one of the factors that has contributed to malnourishments. Individuals cannot cultivate their crops during conflicts, which has an impact on families' ability to produce or purchase quality food[38]. The repeated conflicts in the DRC are a danger not only for peace but for children 's health. Other researchers suggest similar findings, high prevalence of undernutrition, wasting and stunting in high armed conflicts areas including the DRC [38].

Further research will focus on comparative sustainable implementation techniques that would reduce anaemia burden in children and improve child health. Results from this paper highlight the need of a clean and safe environment for children's growth.

Limitations

We used haemoglobin cut off points as suggested by the WHO for children under 5 years, but it was difficult to distinguish the type of anaemia (whether it is iron deficiency anaemia or malarial anaemia or sickle cell anaemia). Therefore, further studies should also determine the type of anaemia.

MDD measurement was limited only to food consumed by children in the last seven days, which may not capture the reality and had many missing values. The results for MDD should be interpreted with caution.

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