Children's Nutritional Status and Low Haemoglobin Level in the Democratic Republic of Congo.

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Abstract

Anaemia is a widespread public health concern. It is estimated that globally 47 percent of young children are anaemic (WHO, 2005). In children, anaemia can impair development and increase susceptibility to infectious diseases. A lack of sufficient food rich in iron and other micronutrients are the commonest cause of the condition. Underweight is an indicator of both short and long term malnutrition and may reflect poor feeding practices or recent episodes of illness.

The paper investigates the link between children's nutritional status (weight-for-age) and anaemia. It aims to answer two the research questions:

(1) Is anaemia endogenous to weight-for-age?

(2) What are common observed socioeconomic and demographic risk factors associated with weight-for-age for anaemic and not anaemic children?

An observed correlation between unobserved covariates that might influence both anaemia and weight-for-age was tested to check whether endogeneity exists in order that the appropriate model could be used.

This study uses a cross-sectional study of 2,479 children aged between 6 and 54 months from the Democratic Republic of Congo. Initially, 24% of children were classified as underweight and 71% were anaemic. Endogenous switching regression models with Full Information Maximum Likelihood were fitted to the data.

The rationality of applying an endogenous switching regression model is that it captures the direct effects of individual observed variable included in the models and the indirect influence of correlated unobserved factors for both weight-for-age and anaemia. If these were ignored then there could be bias in the estimates of the effect of the observed individual variables.

The results indicate that anaemia is significantly associated with child nutritional status (weight-for-age) and most of the risk factors associated with anaemia are also found to be related with weight-for-age. These include age, sex, maternal level of education, whether the mother is anaemic and household wealth status.

Key words: Anaemia, children's nutritional status, weight-for-age, endogenous switching regression models, Full Information Maximum Likelihood.

1. Introduction

Child health outcomes are the results of many factors including genetic, biological, behavioural, socioeconomic, and environmental causes. In the past the determinants of health in general and child health in particular were investigated separately for biological, socioeconomic or behavioural causes. Several researchers, however, initiated the use of a framework in which proximate biological and their underlying socioeconomic and behavioural factors are integrated into a single conceptual model (Cleland and Van Ginneken, 1988, Mosley and Chen, 2003, Briscoe et al., 1990, Bongaarts, 1978). Many potential explanatory factors in these frameworks are interrelated and as a result the integration of all factors into a single model is not without its problems (Zohoori and Savitz, 1997). These problems include the fact that as the model gets more complex some explanatory variables in one equation are then dependant variables in another, with both equations being part of the same model. If appropriate methods are not used, one might end up with endogeneity bias, misclassification and confounding (Briscoe et al., 1990).

In this paper, anaemia in children and other nutritional statuses are influenced by many of the same factors, including dietary intake. Dietary intake is a behaviour which is modifiable by the individual in response to their nutritional status (Zohoori and Savitz, 1997). Therefore, neither anaemia nor child nutritional status can be evaluated without considering the unmeasured variables such as dietary intake. The other problem is that ignoring these issues (e.g. endogeneity) leads to erroneous estimates of the impact of individual variables within the model (Briscoe et al., 1990, Berg and Mansley, 2004a).

Endogeneity bias

The definition of the term ‘endogenous’, as sometimes used in biology, describes something that originates inside a system or the body. When something originates outside the system, it is said to be exogenous. Both endogenous and exogenous are also used in analogous way in some branches of statistics, epidemiology and econometrics. In the context of regression models, a variable that is referred to as endogenous is one whose value is at least partially determined by the value of other variables within the model. For example, a dependant variable Y in a regression equation is said to be endogenous if it is modelled as a function of the set of explanatory variables X, T and Z. Yet, the variable T could also be endogenous, if its value is influenced by any of the other explanatory variable or even by the dependant variable Y. Failure to consider these relationships can lead to endogeneity bias, the statistical bias that arises when an endogenous variable is treated as exogenous (Berg and Mansley, 2004b).

This paper posits that previous studies of anaemia and children’s nutritional status have so far failed to acknowledge the fact that one might be endogenous to the other. Virtually all the studies ignored an important and pervasive source of potential bias which might arise because there might be behaviours which not only affect children’s health (i.e. whether they are anaemic) but that also determine a child’s weight for age. Some of these studies incorporate anaemia with other explanatory variables to predict nutritional status (Chang et al., 1994, George et al., 2000, Kwena et al., 2003). Ignoring the fact that the same unobservable factors that influence anaemia can also influence children’s nutritional status might bring in endogeneity bias.

2. Data and methods

The study uses the Demographic Health Survey from the Democratic Republic of Congo (DRC), conducted in 2007. This is a cross sectional study of 2,749 children aged between 6 and 54 months. Haemoglobin levels were measured in g/dl and were adjusted for altitude. Children with a haemoglobin level below 11 g/dl were classified as anaemic. Weight-for-age is computed using the World Health Organisation anthropometric Software.

The study accounts for possible endogeneity between anaemia and children nutritional status and their relationship with other factors. In this study the joint estimation of both anaemia and weight-for-age is conducted through simultaneous modelling. This method accounts for both observed and unobserved factors and simultaneity between anaemia and weight-for-age using endogenous switching regression models with Full Information Maximum Likelihood (FIML). Endogenous switching regression models can be estimated with two-step estimation method or with Full Information Maximum Likelihood estimation (FIML). It is argued that FIML estimators are most efficient among estimators of simultaneous regression models, as they consider the entire system of equations and all the parameters are jointly estimated (Sung-Yong et al.). The most important aspect of FIML estimators that give it advantage over other estimators is that the estimators obtained by FIML share the same properties of maximum likelihood estimators. They are consistent and asymptotically normally distributed (Sung-Yong et al., Maddala, 1993). The use of endogenous switching regression models provides two benefits: first, the estimation procedure allows the variable anaemia to be treated as endogenous to the weight-for-age and eliminates the inconsistency that may arise from ignoring endogeneity. Finally, it controls for unobserved factors and eliminates potential omitted variable bias (Briscoe et al., 1990). Readers interested in more details about the theory behind endogenous switching regression models as applied in this paper are recommended to read Maddala, 1993.

The basic switching regression model with endogenous switching is defined as the following system of equations:

$$y_{1i} = X_{1i}\beta_1 + \mu_{1i} \quad (1)$$

$$y_{2i} = X_{2i}\beta_2 + \mu_{2i} \quad (2)$$

$$I_{i^*} = Z_{i\gamma} - \varepsilon_i \quad (3)$$

Where Z_i is the exogenous row vectors of dimension $1 * k_j \, (j = 1,2)$ (Maddala, 1993).

Let suppose that the sample observed consists of

$I_i = 1$ if $I_{i^*} > 0 \longrightarrow$ Anaemia yes.

$I_i = 0$ if $I_{i^*} \leq 0 \longrightarrow$ Anaemia no.

The observed y_i (weight-for-age) is defined as:

$$y_i = y_{1i} \text{ if } I_i > 0 \longrightarrow \text{Anaemia yes} \quad (4)$$

$$y_i = y_{2i} \text{ if } I_i = 0 \longrightarrow \text{Anaemia no} \quad (5)$$

$(\mu_{1i}, \mu_{2i}, \varepsilon_i) \sim N_3(0, \Sigma)$, are independently normally distributed.

The model presented by (1)-(3) together with the data (4) and (5) are said to be endogenous switching if $\sigma_{1^*} = \sigma_{2^*} \neq 0$. Where $\sigma_{1^*} = \sigma_{2^*} = 0$ there is no endogeneity and an OLS or logistic regression model is sufficient (Poirier and Ruud, 1981).

It is also suggested that y_{1i}, y_{2i}, I_i^* (1)-(3) is a joint model and has a triviate density function. The data (4) and (5), however, are always bivariate in nature. The data do refer to three dependant variables in one model and each of the three variables is partially observed. I^* is observed as dichotomous variable while the other two (y_1 and y_2) are observed as continuous but conditional to the values of I^*. y_1 is observed only if $I^* > 0$ and y_2 only if $I^* = 0$. Endogenous switching regression models are used as described above. The probability of having anaemia (yes/no) was jointly modelled with children's weight-for-age. Observed socioeconomic and demographic factors were simultaneously accounted and included in both equations.

3. Results

3.1. Subject description

The mean weight-for-age by the selected characteristics (age, sex, maternal level of education, ect.) of the sampled children are given according to whether they are anaemic or not in Table 1. The results suggest that 71% (1769) of the 2,749 children were anaemic and 24% were underweight, with a weight-for-age below the reference population (-2 standard deviations). Anaemic and not anaemic children aged between 2 and 5 years olds have a mean weight-for-age which is lower compared with younger children (less than 2 years olds). The average weigh-for-age for male is lower than it is for female. However, there is no difference in the mean weight-for-age for anaemic children regardless of whether they were breastfeed or not, see Table1.

Table.1. Means weight-for-age for anaemic and not anaemic children by children's characteristics

Variable	Categories	Anaemia Yes		Anaemia No	
		Mean	Sample	Mean	Sample
Anaemia		-1.16	1769	-1.16	710
Age	<2 years	-0.89	779	-0.86	197
	2-5 years	-1.38	990	-1.12	513
Sex	Female	-1.09	876	-0.95	390
	Male	-1.23	893	-1.16	320
Maternal education	None	-1.31	398	-1.25	169
	Primary	-1.26	843	-1.10	294
	Secondary	-0.89	528	-0.85	247
Breastfeeding	No	-1.17	518	-0.97	229
	Yes	-1.16	1251	-1.09	481
Mother anaemic	No	-1.10	805	-1.04	427
	Yes	-1.21	964	-1.06	283
Vegetables	No	-1.23	581	-1.16	251
	Yes	-1.13	1188	-0.99	459
Red meat	No	-1.22	672	-1.20	289
	Yes	-1.13	1097	-0.94	421
Wealth	Poorest	-1.28	349	-1.29	113
	Below average	-1.35	354	-1.08	171
	Average	-1.13	385	-1.04	122
	Above average	-1.07	349	-0.80	160
	Wealthiest	-0.97	332	-1.10	144

3.2. Results from simultaneous endogenous switching regression models

The results indicate that there is strong positive correlation between unobserved factors between weight-for-age and anaemia (Rho 1& Rho 2 are different from zero). Suggesting not only that almost the same observed factors that influence childhood probability of having anaemia are also related with children's weight-for-age but so do the unobservable factors. This is to say that anaemia is endogenous to weight-for-age. Models that will be interpreted include the following:

- One model with weight-for-age as the outcome for anaemic children (see Table 2)
- The other model with weight-for-age as the outcome for no anaemic children (see Table 2). The findings suggest that age, sex, maternal level of education, whether the mother is anaemic and household wealth status are factors associated with weight-for-age for anaemic children in DRC (Table 2). However, whether or not the child was breastfeed, consumed green leafy vegetables or meat are not found to be related with weight-for-age among anaemic children. Factors that are associated with weight-for-age for children who are not anaemic are sex, maternal level of education, the consumption of red meat and households wealth status.

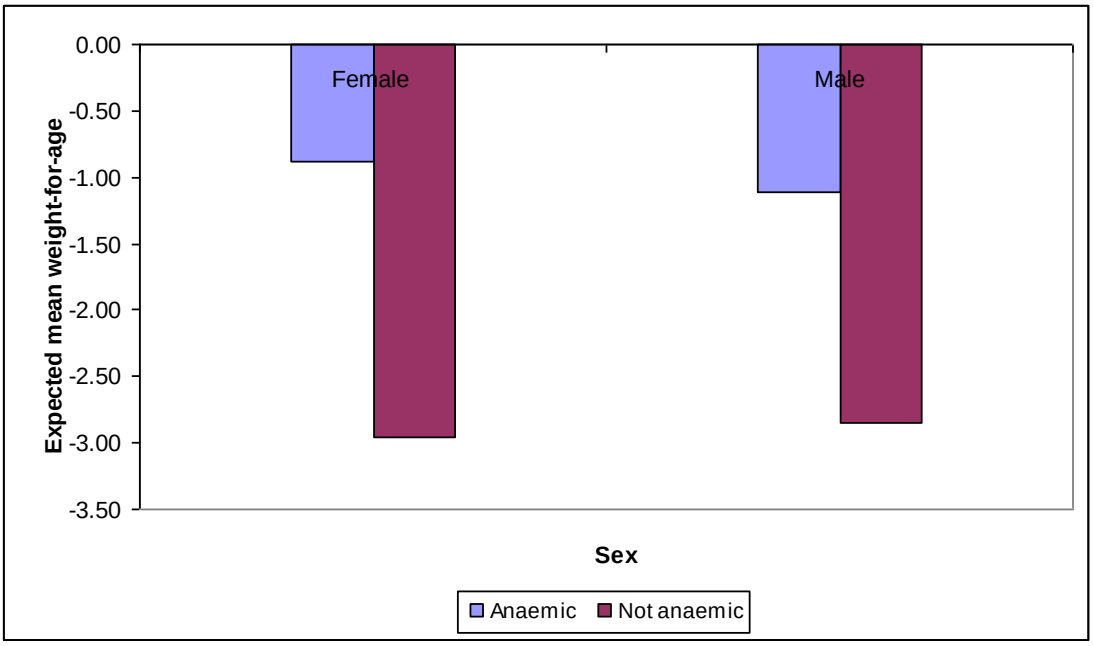
Table 2. Estimated mean weight-for-age for anaemia and not anaemic children by the selected characteristic in DRC

Variable	Categories	weight_For-age Anaemia Yes		weight_For-age Anaemia No		Anaemia	
		Est	P-value	Est	P-value	O.R	P-value
Constant	Constant	-0.497		-2.098			
Age	<2 years(Ref)					1	
	2-5 years	-0.300	***	-0.025		0.99	***
Sex	Female(Ref)					1.00	
	Male	-0.235	***	-0.251	**	1.15	**
Maternal education	None (Ref)					1.00	
	Primary	-0.014		0.095		1.15	**
	Secondary	0.384	***	0.353	***	0.97	
Breastfeeding	No(Ref)					1.00	
	Yes	-0.087	NS	-0.094	NS	1.05	NS
Mother anaemic	No(Ref)					1.00	
	Yes	-0.282	***	-0.225	NS	1.46	***
Vegetables	No(Ref)					1.00	
	Yes	0.051	NS	0.052	NS	1.03	NS
Red meat	No (Ref)					1.00	
	Yes	-0.006	NS	0.19	*	1.03	NS
Wealth	Poorest (Ref)					1.00	
	Below average	0.012		0.293	*	0.80	***
	Average	0.104		0.152		1.05	
	Above average	0.262	**	0.519	***	0.88	
	Wealthiest	0.326	***	0.188		0.96	
P1(Rho 1)		-0.681	0.059				
P2(Rho 2)		-0.448	0.267				

Est: Estimates from endogenous switching regression models;
Ref: reference category; NS: Not significant
****: p-value at 1% ** : p-value at 5% *:p-value at 10%*
Rho 1 is the correlation coefficient between equations for weight-for-age and anaemia yes.
Rho 1 is the correlation coefficient between equations for weight-for-age and anaemia no.

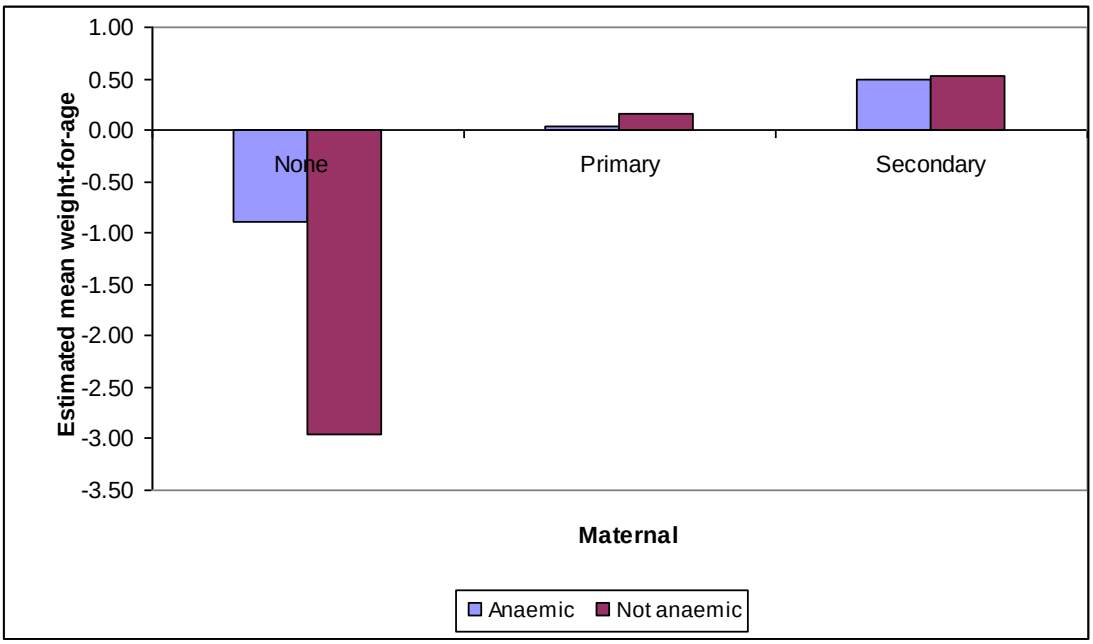
For both anaemic and not anaemic children, sex, maternal level of education and household wealth status are common important factors that are influencing children's nutritional status. As depicted in Figure 1 for both male and female children, not anaemic children have an average mean weight-for-age which is worse (far below -2 standard deviations) compared with those children who are anaemic. This is not as one would expect.

Fig. 1. Expected mean weight-for-age for anaemic and no anaemic children in the Congo by sex



Maternal level of education is another important factor related with children's nutritional status. For both anaemic and no anaemic children the results suggest that the estimated means weight-for-age increases with an increased maternal level of education see Fig.2. These results support previous findings suggesting that maternal level of education can have a positive impact on children's well being (Gacek and Chrzanowska, 2009).

Fig. 2. Mean weight-for-age for anaemic and not anaemic children in the DRC by maternal level of education



Household wealth status is among many other factors that influence on children's nutritional status in DRC. It is found that the estimated mean weight-for-age increases with an increased household wealth status for anaemic children. However, it is not the case for not anaemic children. For not anaemic children there is not significant difference in the mean weight-for-age between children from households with average wealth status and those children from wealthiest households. Whether children consumed red meat was found to be related with their nutritional status only among children who where not anaemic. On average, no anaemic children who consumed red meat have a weight-for-age which is 0.190 times higher than those who did not (Table 2).

4. Discussions

The results suggest that in the DRC whether children are anaemic or not have an impact on children's nutritional status. Most of the factors associated with anaemia during childhood are also related with children's weight-for-age. For anaemic children, the means weight-for-age are significantly different between the age groups, sex, maternal level of education, whether the mother is anaemic and between household wealth status. The average weight-for-age, for not anaemic children, however, differ only between sex, maternal level of education, whether children consumed red meat and by household wealth status. Children of anaemic mothers are not only more likely to be anaemic but also have a low mean weight-for-age. The intervention to address children's nutritional status in DRC should also include their mothers. The consumption of red meat has a positive impact on children nutritional status for not anaemic children. This support the findings form previous study which reported a low intake of meat in diet and a reliance on bulky cassava dough balls as in most of the regions in this typical equatorial African population (Barclay et al., 2003). For both anaemic and not anaemic, however, there were no significant differences in the means weight-for-age among those children who were breastfed or not and whether children consumed green leafy vegetables or not.

Endogenous switching regressions reveal that the correlation found between anaemia and weight-for-age might partially stems to problems such as omitted variables (on the basis of unobserved factors) and perhaps on the simultaneity between anaemia and weight-for-age. The rationality of endogenous switching regression model applied in here is that $\rho 1$ and $\rho 2$ capture the influence of correlated unobserved factors for weight-for-age and anaemia which it is believed that once ignored could bias the effect of other individual variables included in the model. Possible unobserved factors include the extrinsic factors such as economic decline, demographic transitions, political conflicts and cultural factors that are even more important in determining nutritional status and its relation to children health and well being.

5. Conclusions

The aim of this paper was to use appropriate analytical methods and investigate the links between anaemia and children's nutritional status (weight-for-age). The study design limits the interpretation of cause and effect; however, regardless of causality, these findings suggest that both, anaemia and weight-for-age are influenced by the same observed and unobserved factors. Anaemia is endogenous to weight-for-age, almost the same socioeconomic and demographic factors that could expose children to the risk of having anaemia are also related with children's weight-for-age. Possible unobserved factors include the extrinsic factors such as economic decline, demographic transitions, political conflicts and cultural factors that are even more important in determining nutritional status and its relation to children health and well being in DRC. Dietary interventions to treat anaemia and prevent children nutritional status are important and should address several micronutrients in addition to maternal education and food availability and access.

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