Household Economic Well-being and Child Health in the Democratic Republic of Congo

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By

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Abstract

Health is both a direct component of human well-being and a form of human capital that increases an individual's capabilities and opportunities to generate income, and reduces vulnerability. It is argued that these two views are complementary and both can be used to justify increased investment in health in developing countries. Therefore, investment in child health constitutes a potential mechanism to end the intergenerational transmission of poverty. This paper examines the empirical impact of household economic well-being on child health, and the gender differences in effects using the Democratic Republic of the Congo (DR Congo, or DRC) Demographic and Health Survey conducted in 2014. A series of econometric tools are used; the control function approach appears to be the most appropriate strategy as it simultaneously removes structural parameters from endogeneity, the sample selection and heterogeneity of the unobservable variables. Results suggest a significant positive effect of household economic well-being on child health. However, the magnitude of the effect varies by gender of household head; children from households headed by males appear healthier compared to those from female-headed households. In the context of DR Congo, female-headed households often have a single parent, therefore, the economic well-being effect on child health in the male sub-sample can be considered to include the unobserved contribution of women. These results have implications for public interventions that enable women to participate in paid labour market activities as a means of improving household economic well-being, which in turn could improve child health.

Key words: Household, economic well-being, child health, underweight, Democratic Republic of the Congo

1.0 Introduction and background

Pioneering research on human capital (Becker, 1964; Schultz, 1960; Mushkin, 1962) placed an emphasis on education. Only later was health afforded the same importance (Grossman, 1972b). As a component of human capital, health improves an individual's productivity and, hence, a community's welfare (Bloom and Canning, 2000). This is the main reason why health became a major concern for national and international stakeholders. In this regard, the World Health Summit in 1990 set the goal of achieving "health for all" in the year 2000. However, while the indicators of some programmes carried out in sub-Saharan Africa to combat disease indicate some improvements, the impact on access to health care and health status remains limited. In order to improve this, the international community prioritized health, especially for children under five, as part of the Sustainable Development Goals (SDG, with a target date of 2030), which followed on from the Millennium Development Goals (MDG, for which the deadline was 2015).

In the DRC, improving children's health remains an important challenge; although there has been some progress, the indicators remain unsatisfactory. The Demographic and Health Surveys (DHS) suggest that the percentage of children under five who are underweight remains high compared to the African average, even though it dropped from 25.1% in 2007 to 23% in 2014. It is also still higher than the 16.8% target in the MDG framework. The high number of underweight children should be seen in the context of the overall food security situation in the country, which remains of great concern. With a score of 41, the DRC was in last place, 82nd out of 82 countries, in the 2010 Global Hunger Index, having fallen significantly since 1990 into the "extremely alarming category" (Von Grebmer et al., 2011). The DHS reports indicate that children from the low quintiles of household economic well-being (poor households) are more often underweight compared to those from wealthy households. Children in poor households also face more health problems, and these households have high infant and child mortality rates.

Empirical studies in economics have focused on the relationship between parents' socioeconomic background, such as income and level of education, and their children's health status. This relationship was explored by using a set of anthropometric measures, subjective and objective indicators to measure the children's health status (Becker and Tomes, 1986; Meer et al., 2003; Chalasani and Rutstein, 2014). A strong relationship was reported between maternal education, household income and child health. However, these studies have hardly been able to analyze the mechanisms

through which the underlying variables affect health indicators. Although the literature has shown that children from poor families experience more health problems than those from well-to-do families (Case et al., 2005), this does not necessarily translate into a causal relationship between a family's socioeconomic situation and the children's health status (Rosenzweig and Schultz, 1983). Moreover, most of the research in this area has only used income as a measure of household economic well-being in analyzing the effects on child health and have therefore ignored the importance of moving beyond income. Researchers have also largely neglected the problem of endogeneity caused by the backward effect (simultaneity) between household economic well-being and child health. Most of these studies covered developed countries, where family structures differ radically from those of developing countries.

This paper investigates the impact of household economic well-being on child health in DR Congo by analyzing trends in children who are underweight. The potential heterogeneous effect according to households' level of economic well-being is also addressed. The hypothesis is that the richest households would be more likely to invest in seeking health care and good health behaviours that would reduce the risk of children becoming underweight. This study is of great importance in terms of policy that is rooted in the international community's commitment to end all forms of malnutrition by 2030 according to the United Nations' SDG. Thus, this study will be a major contribution to informing policies aimed at achieving the third SDG in DR Congo. The rest of the paper is organized as follows: Section 2 presents the literature review, while Section 3 deals with the data, methodology and measure of variables. Section 4 presents the main findings and Section 5 concludes the paper.

2.0 Literature Review

Health is a commodity for which there is no market and that must be produced within the household (Becker, 1965; Grossman, 1972a, b). Household living conditions are, therefore, considered important as a determinant of the health of all members of a household, particularly the children. Economic theory suggests that some parents from poor households invest little in the health of their children (Becker and Tomes, 1979, 1986). Concerning the United Kingdom, Case et al. (2005) found that the children from families in the lowest income bracket generally had poor health at school age compared to those from families in higher income brackets. For Scandinavian countries, the research by Lundberg (1993) showed that living conditions in childhood and the household's social status and economic conditions had effects on health that went beyond adolescence. There are indeed a number of mechanisms that underlie the relationship between household economic conditions and child health. From their review of empirical studies, Case et al. (2005) concluded that more attention should be paid to health as a potential mechanism through which the intergenerational transmission of economic status happens. An adult individual's state of health is influenced by a number of factors, ranging from predetermined genetic endowment and the experiences he/she went through in childhood and adolescent life, to his/her style in his/her adult life.

From an economic perspective, it could be argued that parents invest in the health of their children by spending their time and money on various dimensions. Their choice of diet and nutrition for their children, their awareness of and actions against diseases and injuries, the quality of health care they seek for them, the area they reside in, and the type of housing and environment they live in, are all examples of parental decisions that are likely to have long-term effects on their children's health. The costs associated with the parents' investment in their children's health can be considerable. Economic theory predicts that wealth and income influence the actions taken by parents in order to protect their children's health (Becker and Tomes, 1979, 1986). In addition, when parents are too poor to take out a loan to guarantee the future of their children, they will tend to invest less in the latter's health. Even though the literature has shown that children from poor families experience more health problems than those from well-to-do families (Case et al., 2005), it does not necessarily translate into a causal relationship between a family's socioeconomic situation and their child's health.

Moreover, the literature does not provide enough information on household economic well-being mobility and its consequences on child health. Therefore, the empirical strategy used by certain studies reported in the existing literature can be questioned. Indeed, household socioeconomic status could have a significant influence on child health without excluding reciprocal causality between the two variables. This reciprocal causality relationship should therefore be taken into account in the analysis. That is why recent empirical studies have revisited the debate on the relationship between household socioeconomic status and child health. In particular, panel data were used to deal with the issue of the endogeneity of the economic status in the relationship. These studies reported studies that do not indicate a clear causal relationship between economic status and child health (Meer et al., 2003; Case et al., 2005; Bender and Habermalz, 2005), or they reported that while the effect does exist, it is a very weak one (Adams et al., 2003; Contoyannis et al., 2004; Frijters et al., 2005; Lindahl, 2005).

The literature also reports studies that have focused on the relationship between households' ownership of resources and their children's health (Chalasani et al., 2012; Chalasani and Rutstein, 2014). Overall, it has been acknowledged that household economic conditions influence the physical health of the child and could hinder the formation of human capital over his/her entire life cycle (Almond et al., 2005; Currie and Stable, 2003; Case et al., 2005; Ding et al., 2006; Black et al., 2005). From the literature reviewed above, it can be observed that household economic conditions influence child health differentially depending on country. In addition, the results vary according to the methodology used. Moreover, the research reported in the literature does not tell us much about the state of research in developing countries (Coneus and Spiess, 2008), and in the Democratic Republic of the Congo in particular. This study aims to contribute to the literature by exploring the mechanisms underlying the relationship between household economic well-being and child health in the Democratic Republic of the Congo.

3.0 Methodology

3.1 Data

The data used in this study are from the 2013–2014 Demographic and Health Survey (DHS) conducted by the DR Congo Ministry of Planning, the Ministry of Public health, MEASURE DHS and ICF International, in collaboration with UNICEF and other international donors. The sample was selected stratum by stratum. Thus, the sample was based on an area sample, stratified at the level of primary units and selected over multiple stages. The final sampling unit used was the cluster (quarter or village) and, in total, 540 clusters were selected. A total of 18,360 households (5,474 from urban areas grouped into 161 clusters, and 12,886 from rural areas grouped into 379 clusters) were selected. The objective of the DHS was to produce representative results at the national as well as urban, rural and provincial level (Ministère du Plan et al., 2014). Within households, questionnaires were administered to women aged 15 to 49 years old. Information on birth history, individual characteristics, health behaviour, and child health was collected. Data for the analysis were taken directly from the children's records and from the women surveyed; only the last-born child who was younger than five years old was considered.

3.2 Analytical Framework

The empirical analysis starts from the fact that investment in economic well-being is an important input in the production of child health within a household, and the two phenomena are correlated. Thus, the level of household economic well-being and child health are simultaneously determined and this calls for an estimation approach that takes into account the endogeneity (Wooldrige, 2002). The estimation system to be used is shown in equations (1)-(4).

$$w = x\sigma_w + \varphi z + \varepsilon_1 \quad (1)$$

$$h = x\sigma_h + \gamma w + \varepsilon_2 \quad (2)$$

where w is economic well-being and h is child health; economic well-being is endogenous in the child health production function. Economic well-being is captured by the indicator constructed from households' assets and housing attributes. Child health is measured by being underweight. Moreover, x is a vector of sociodemographic

variables that are also included in the determination of economic well-being (w) and child health (h); z is a vector of instrumental variables that influence the economic well-being without influencing child health; σ, φ and γ are parameters to be estimated, and ε_1, ε_2 are the error terms. Given that Equations 1 and 2 are simultaneously determined, the error terms of these two equations are correlated, which leads to bias and an inconsistency in the OLS estimates. Therefore, Equations 1 and 2 are estimated with a method where the first step is to find valid instruments for the observable variables that affect household economic well-being (w) without affecting child health (h).

Endogeneity and Identification Strategy

The potential instruments of household economic well-being are the distance to reach the nearest health centre and the time to the nearest water source. However, let us specify that there could be heterogeneity in child health status due to the nonlinear interaction between economic well-being and some unobservable or omitted variables, and that this could introduce a bias in the estimation of the structural parameters. To address this potential heterogeneity, we use the control function approach (Mwabu, 2008; Baye, 2010). Equation 2 can now be rewritten as:

$$h = \beta_0 + \sigma x + \gamma w + \beta_1 \hat{\varepsilon}_3 + \theta(\hat{\varepsilon}_3 * w) + u \quad (3)$$

where, $\hat{\varepsilon}_3$ is the fitted residuals of economic well-being (w), $(\hat{\varepsilon}_3 * w)$ is the interaction of the fitted economic well-being residual with the actual value of the w; β_0, β_1 and θ are parameters to be estimated and u is the error term. Thus, the instrumental variable estimates of Equation 3 are unbiased and consistent only when: (a) the expected value of the interaction between economic well-being and its residual $(\hat{\varepsilon}_3 * w)$ is zero or the interaction between child health and its fitted residual is linear, and (b) there is no sample selection problem. If the correlation is non-linear, then the control function approach is required. When the two control function variables $(\hat{\varepsilon}_3)$ and $(\hat{\varepsilon}_3 * w)$ are generated, the estimation of Equation 3 will remove the structural estimates of the parameters of child health from potential simultaneity bias and unobserved heterogeneity. However, the estimates of Equation 3 may not be applicable to all children because children whose weights were not registered are not reflected in Equation 3. To address potential selection bias, Equation 4 is introduced:

$$g = 1[t\delta' + \varepsilon_4 \geq 0] \quad (4)$$

where, $g = 1$ if the child weight-for-age z-score is observed, and 0 otherwise; g is an indicator function of sample selection; tt is a set of exogenous variables (comprising the instruments) that determine the selection into the sample; δ' is a vector of parameters to be estimated and $\varepsilon_4\varepsilon_4$ is a perturbation term.

3.3 Variables

The outcome variable is being underweight, a dichotomous variable. Underweight is defined as weight-for-age z-score (WAZ) below -2 standard deviations. WAZ and/or underweight have been used in many studies on the socioeconomic determinants of child health status (WHO, 2006; Baye, 2010; Adeoti and Awoniyi, 2014; Frimpong et al., 2016). The weight-for-age measure is a good reflection of the overall child nutritional status and it can be used to monitor the increase of child weight. The weight-for-age measure can serve as a composite index; it does not seek to determine whether the child is small, but asks whether the child is well fed. In addition, it does not seek to determine whether the child is large, but rather whether the child is emaciated. The weight-for-age measure reflects signs of deficiency or temporary lack of food, or recent or current episodes of illness. It was an MDG indicator and is still an issue targeted by the third UN SDG.

Following the theoretical models of Rosenzweig and Schultz (1983) and Mosley and Chen (1984), a number of independent variables of proximate and socioeconomic determinants are included in our model of being underweight. The independent variable of most interest is the economic well-being indicator, a continuous variable constructed by the DHS using the method of Principle Component Analysis (PCA). In addition to the indicator of economic well-being, there are some key variables related to household economic well-being: possession of livestock, arable land and radio; use of an improved water source, unshared and improved toilet; and the presence of electricity in the home. Other control variables include a set of child characteristics (age, gender, birth size, birth weight, and twin child), maternal characteristics (age, educational attainment, employment status, body mass index, or BMI), and household characteristics (household size, gender of the household head, place of residence, religion of household head). Finally, there are instrumental variables (distance in kilometres to reach the nearest health centre, and time in minutes to get to the nearest water source) for controlling the endogeneity, and variables controlling unobservable variables and sample selection (predicted residuals of economic well-being indicator, interaction between the well-being indicator and its residuals, and inverse of the Mills ratio).

4.0 Results

4.1. Descriptive Statistics

Table 1 presents the summary statistics describing the analytic sample. It can be seen that 21 % of children in the sample are underweight. That percentage is much higher than the expected value of 2.3 % found in a healthy population. The average value of household economic well-being indicator is 0.15. The distribution of household economic well-being by region is presented in Table 2.

Table 1 Summary statistics of variables short-listed for regressions

Variable	Obs.	Mean	Std. Dev.	Min	Max
Outcome variable					
Child underweight	5367	0.21	0.41	0	1
Independent variable of interest					
Household economic well-being index	5367	0.15	0.15	0	1
Key variables of household economic well-being					
Household has livestock	5367	0.50	0.49	0	1
Number of hectares of agricultural land	5367	14.13	9.89	0	99
Household uses water from improved source	5367	0.48	0.49	0	1
Household uses unshared and improved toilet	5367	0.39	0.48	0	1
Household has improved floor material	5367	0.17	0.38	0	1
Household has electricity	5367	0.13	0.34	0	1
Household has radio	5367	0.46	0.49	0	1
Household has at least a mobile phone	5367	0.35	0.47	0	1
Child characteristics					
Child is male	5367	0.497	0.50	0	1
Child age in months	5367	28.44	17.16	0	59

Variable	Obs.	Mean	Std. Dev.	Min	Max
Child age squared/10	5367	110.34	103.13	0	348
Child is twin	5367	0.03	0.18	0	1
Child birth weight is high	5367	0.88	0.31	0	1
Child birth weight	5367	3.39	0.71	0.8	8
Maternal characteristics					
Mother's age in years	5367	29.06	6.93	15	49
Mother's age squared/10	5367	89.25	42.63	22.5	240
Mother's BMI	5367	22.05	3.49	12.6	52.5
Mother's number of years of education	5367	5.62	3.88	0	18
Mother is employed	5367	0.74	0.43	0	1
Household characteristics					
Household head is female	5367	0.19	0.39	0	1
Household head's age in years	5367	38.83	11.81	16	95
Household head's age squared/10	5367	164.73	107.45	25.6	902
Household size	5367	6.82	2.91	1	24
Household is urban	5367	0.37	0.48	0	1
Household head is Catholic	5367	0.281	0.44	0	1
Household head is Protestant	5367	0.27	0.44	0	1
Household head is other Christian	5367	0.37	0.48	0	1
Instruments of household economic well-being					
Distance to nearest health centre	5367	1.83	1.17	0	29
Time to reach nearest water source (minutes)	5367	32.37	30.13	0	360
Controls for unobservable variables					
Predicted residuals of economic well-being	4968	7.64e-12	0.105	-0.29	0.39
Interaction between well-being and its residuals	4968	0.011	0.054	-0.11	0.38
Inverse of Mills ratio	4968	0.439	0.029	0.34	0.66

Source: Author's calculation using the 2014 DRC's DHS data.

Table 2: Distribution of economic well-being by quintile across region, 2007 and 2014

Region	Poorest		Second		Middle		Fourth		Richest	
	2007		2007	2014	2007	2014		2014		2014
Kinshasa	0.5	0.0	0.5	0.0	1.6	0.0	9.5	2.9	87.4	97.1
Congo Central	11.3	5.5	17.7	13.3	25.5	25.3	25.1	32.4	20.4	23.5
Bandundu	29.7	22.6	31.3	33.5	28.5	24.5	9.9	16.6	0.6	2.8
Équateur	20.6	38.5	34.5	24.3	30.8	21.1	11.8	13.0	2.2	3.1
Orientale	17.6	25.7	34.7	24.2	28.9	22.5	13.9	18.4	4.8	9.3
North Kivu	15.4	13.3	15.8	17.2	26.0	19.6	35.8	26.9	7.0	22.9
Maniema	11.7	7.8	9.3	13.2	16.3	25.9	39.4	43.1	23.3	10.1
South Kivu	20.9	20.5	27.7	21.2	26.4	33.1	23.0	20.8	2.0	4.4
Katanga	30.3	16.0	6.5	16.1	13.6	17.6	17.6	17.3	32.0	33.0
Kasaï -Oriental	11.8	20.7	16.3	19.4	18.8	19.3	38.5	24.6	14.6	16.0
Kasaï-Occidental	24.4	31.1	20.6	22.2	26.0	18.0	27.1	20.9	2.0	7.8
Urban	4.1	4.8	5.8	3.3	13.7	7.4	30.8	27.4	45.6	57.1
Rural	29.0	27.9	31.3	28.7	27.3	26.5	11.7	16.1	0.7	0.7
National	18.3	20.0	20.4	20.0	21.5	20.0	19.9	20.0	20.0	20.0

Source: Computed by author using 2007/2013–2014 DHS in DR Congo.

According to Table 3, the prevalence of underweight children varies according to the household economic well-being characteristics. Indeed, the proportion of children who are underweight declined steadily with the level of household well-being from 18.3% for children in the poorest households to 6.9% for children in the richest households. Concerning the place of residence, it is in rural areas where the prevalence of being underweight is higher, with 17.4% against 11.5% for urban areas. Regarding the prevalence of being underweight by gender, it is 17.3% for boys and 14.2 % for girls.

Table 3: Nutritional status of children under 5 in 2014 (%)

Characteristic	Height-for-age		Weight-for-height		Weight-for-age	
	-3SD	-2SD	-3SD	-2SD	-3SD	-2SD
Poorest	27.9	21.8	3.2	5.4	9.7	18.3
Poor	27.5	22.9	3.4	5.9	9.7	17.8
Middle	24.8	21.5	3.2	5.8	7.5	16.3
Rich	20.3	21.4	2.3	4.5	6.5	14.1
Richest	7.3	14.6	1.2	2.7	1.4	6.9
Overall	23.4	21.1	2.9	5.1	7.9	15.6
Urban	15.3	19.1	1.8	4.2	4.7	11.5
Rural	26.7	21.9	4.1	3.3	8.9	17.4
Girls	21.2	20.4	2.3	4.3	7.0	14.2
Boys	25.6	21.8	3.4	6.0	8.4	17.3

Source: Computed by author using the 2007/2013–2014 DHS in DR Congo.

The analysis of being underweight by region (see Table 4) suggests significant disparities among the regions of DRC. Table 4 indicates that the percentage of children who were underweight is lower in the Kinshasa region compared to other regions. In the Kinshasa region, the percentage of children with a weight-for-age score below minus two standard deviations (-2SD) from the median population was 2.6% in 2007, compared to 1.7% in 2014, according to the World Health Organization (WHO). From this comparison, it can be seen that there was a decrease in the prevalence of underweight children in Kinshasa from 2007 to 2014. Unfortunately, in some regions the percentage of underweight children increased over the same period. For example, in the Congo Central province the rate of severe underweight children (weight-for-age below -3SD) was 7.5% in 2007, compared to 11.0% in 2014, and the rate of moderate underweight children also increased from 25.6% to 27.3%.

Table 4: Prevalence of underweight children under 5 by region

Regions	Underweight in 2007		Underweight in 2014	
	< -3SD	< -2SD	< -3SD	< -2SD
Kinshasa	2.6	14.8	1.7	5.5
Congo Central	7.5	25.6	11.0	27.3
Bandundu	9.0	27.8	7.0	25.3
Équateur	14.3	29.2	5.2	19.4
Orientale	6.4	21.4	6.0	20.2
North Kivu	6.1	20.0	5.5	21.4
Maniema	7.0	30.8	10.3	26.0
South Kivu	2.9	18.1	13.0	31.9
Katanga	6.5	20.2	5.9	20.3
Kasaï-Oriental	12.9	30.8	9.2	25.6
Kasaï-Occidental	9.6	30.3	10.2	30.5

Source: Computed by author using the 2007/2013–2014 DHS in DR Congo.

The highest percentage of severe underweight children in 2007 is in the province of Equateur, at 14.3%, followed by the province of Kasaï-Oriental with 12.9%; while the provinces with the highest percentage of children with a weight-for-age score below -2SD is Maniema (30.8%) and Kasaï-Oriental (30.8%), followed by Kasaï-Occidental (30.3%) and Équateur (29.2%). In 2014, the province with the highest percentage of children with a weight-for-age score below -3SD is Kivu South (13.0%), followed by Congo Central (11.0%) and Maniema (10.3%). The highest percentage of children with a weight-for-age score below -2SD is found in Kivu South (31.9%) followed by Kasaï-Occidental (30.5%) and Congo Central (27.3%). The provinces that have a high percentage of children that are underweight are among the first five poorest DRC provinces (see, for example, Moummi, 2010).

Regarding the possession of assets, 50% of households captured in the sample own livestock, while the average number of hectares of arable land owned by households is about 14. The proportion of households that use water from an

improved source is 48%, and 39% of households use an unshared and improved toilet. Moreover, only 17% of households have improved floor material in their homes, and access to electricity is very low (13%).

On average, children captured in the sample are aged about 28 months old, and slightly more than 50% are girls. About 88 % of children are big at birth and the average birth weight is 3.39 kilograms. The average mother's age is 29. The average number of years of mothers' education is about 6 years; in the DRC that number corresponds to the primary educational level. Concerning employment status, 74% of mothers in the sample were employed at the time of the survey. Within household characteristics, it is noted that on average a household has about 7 members. This household size remains high compared to the African average and it should be viewed in relation to the high fertility rate observed in the country (7 children per woman in 2014), which has implications such as increased deprivation, and therefore poverty, for most households.

4.2. Econometric Results

Prior to reporting results from the estimation of the child health production functions, it is important to recall that household investment in economic well-being could correlate with the error term, which will bias the OLS estimate. For instance, it could be that households with a propensity to provide appropriate nutrition to their children may also be the ones who are likely to acquire assets and to improve housing and habitat, which will bias the estimates upwards. It is thus important to properly estimate the structural parameters.

4.2.1 Estimation of Child Health Production Function under alternative Assumptions

Table 5 presents estimates of the structural forms of the child health production function under different assumptions. Equation 1 is Probit estimates of the underweight structural parameters; Equations 2 and 3 are the joint maximum likelihood estimates of the Heckman selection (heckprob stata command) and the structural parameters correcting for potential sample selection bias, respectively. Equation 4 is the first stage of instrumental variable (IVProbit) estimation or the reduced form economic well-being equation; Equation 5 is the IVProbit estimates of the structural parameters accounting for potential endogeneity; Equations 6 and 7 are control function estimates. Equation 6 is the IVProbit estimates correcting for potential sample selection, and Equation 7 the IVProbit estimates correcting for both potential sample selection and heterogeneity captured by the non-linear interaction term.

The estimates indicate that by considering the household economic well-being as exogenous, it significantly reduces the risk of a child being underweight by -34%, controlling for other covariates. This gives an indication that child health is strongly positively associated with household economic well-being. But if the

residuals from the underweight equation are correlated with the probability that weight-for-age z-scores (WAZ) were not reported for some children, conditional on the determinants of WAZ, the estimates in Equation 1 would be adulterated by sample selection bias (Heckman, 1979). In addition to correlates of the structural equation, the sample selection equation includes identifying variables that affect selection, but not the underweight variable.

The sample selection equation and the structural underweight equation are jointly estimated by the Heckman procedure using the Maximum Likelihood (ML) method, reported in Equations 2 and 3 of Table 5, respectively. The correlation of the errors between the selection model and the being underweight equation is shown in the Wald test of independent equations (or LR test of independent equations in the case of stand errors) in Table 5 (Equations 2 and 3), which indicates that $\rho = -0.984$ $\rho = -0.984$ with $\text{p\_value} = -0.1368.$ $\text{p\_value} = -0.1368.$ Therefore, we cannot reject the null hypothesis that $\rho = 0,$ $\rho = 0,$ which requires correcting the potential sample selection bias. Taking into account potential sample selection bias, the coefficient of household economic well-being in the structural underweight equation is lower than the Probit estimate controlling for other correlates. The Probit model generates a marginal effect of economic well-being on children who are underweight of -0.335, which is too high in relation to the Heckman estimate of -0.260. The indication is that accounting for sample selection bias downgrades the Probit estimates marginally by 7.5% in terms of probability (risk).

Table 5: Estimation of child health production function, marginal effects (dependent variable = underweight)

Method and variable	Probit	Heckman selection ML		IVProbit		Control function approach	
	Underweight (1)	WAZreport (2)	Underweight (3)	Well-being (4)	Underweight (5)	Linear (6)	Non-linear (7)
Economic well-being indicator	-0.335**(0.056)	-------	-0.260**(0.084)	-------	-0.468***(0.105)	-0.465***(0.145)	-0.408***(0.154)
Child gender	0.058**(0.011)	-0.056(0.061)	0.063**(0.016)	0.236***(0.045)	0.064***(0.012)	0.052***(0.016)	0.052***(0.016)
Child age	0.007**(0.001)	0.006**(0.002)	0.006**(0.002)	0.024***(0.005)	0.007(0.001)	0.007***(0.002)	0.007***(0.002)
Child age squared/10	-0.001*(0.000)	-0.000(0.000)	-0.000(0.000)	-0.002*(0.001)	-0.000*(0.000)	-0.001(0.000)	-0.000(0.000)
Child is twin	0.141**(0.027)	-0.455(0.140)**	0.160**(0.040)	0.587***(0.112)	0.159***(0.032)	0.086*(0.048)	0.084*(0.048)
Child birth size	-0.035(0.018)	0.099(0.100)	-0.045(0.027)	-0.123*(0.074)	-0.033(0.020)	-0.030(0.027)	-0.031(0.027)
Child birth weight	-0.056**(0.009)	0.035(0.045)	-0.062**(0.013)	-0.206***(0.037)	-0.056***(0.010)	-0.064***(0.013)	-0.065***(0.013)
Mother's age	-0.008(0.006)	0.053(0.032)	-0.013(0.009)	-0.032(0.026)	-0.009(0.007)	-0.008(0.009)	-0.008(0.009)
Mother's age squared/10	0.001(0.001)	-0.007(0.005)	0.002(0.001)	0.004(0.004)	0.001(0.001)	0.001(0.001)	0.001(0.001)
Mother's BMI	-0.013**(0.002)	-0.032(0.009)**	-0.007*(0.003)	-0.043***(0.009)	-0.012***(0.002)	-0.014***(0.004)	-0.014***(0.004)
Mother's education	-0.004*(0.002)	0.014(0.010)	-0.004(0.003)	-0.003(0.010)	-0.001(0.002)	0.000(0.004)	0.000(0.004)
Mother's employment status	-0.006(0.013)	0.003(0.070)	-0.003(0.019)	-0.021(0.054)	-0.006(0.015)	-0.004(0.019)	-0.004(0.019)
Household head's age in years	-0.000(0.003)	-0.036(0.017)*	0.005(0.005)	0.009(0.013)	0.002(0.003)	-0.004(0.005)	-0.004(0.005)
Household head's age squared/10	0.000(0.000)	0.002(0.002)	-0.000(0.000)	-0.001(0.001)	-0.000(0.000)	0.000(0.001)	0.000(0.001)
Household size	0.004(0.002)	0.085(0.013)**	-0.004(0.004)	0.020**(0.010)	0.005***(0.003)	0.009*(0.006)	0.009*(0.005)
Household head is Catholic	0.002(0.023)	-0.020(0.134)	-0.023(0.035)	-0.007(0.011)	-0.012(0.039)	-0.037(0.033)	-0.038(0.033)
Household head is Protestant	-0.009(0.023)	-0.116(0.132)	-0.016(0.035)	-0.007(0.011)	-0.023(0.039)	-0.048(0.034)	-0.049(0.034)
Household head is other Christian	0.003(0.023)	-0.099(0.131)	0.001(0.034)	0.016(0.011)	-0.003(0.039)	-0.017(0.033)	-0.016(0.033)

Identification variables							
Distance to nearest health centre	-------	-0.002(0.001)	-------	-0.001***(0.000)	-------	-------	-------
Time to the nearest water source	-------	-0.063*(0.051)	-------	0.133***(0.004)	-------	-------	-------
Controls for unobservable							
Pred. residuals of econ well-being	-------	-------	-------	-------	-------	0.190*(0.158)	0.386(0.240)
Econ. well-being $\times\times$ its residuals	-------	-------	-------	-------	-------	-------	-0.626**(0.576)
Inverse of the Mills ratio	-------	-------	-------	-------	-------	0.149(0.557)	0.158(0.557)
Constant	-------	1.417(0.614)*	-------	0.008(0.035)	-------	-------	-------
Number of obs. [Censored obs.]	5367	4909[541]		4368		4368	
Wald chi2[df ; p-value]	-------	181.07[19 ; 0.0000]		330.07[19 ; 0.000]		203.1[21 ; 0.00]	202.9[22 ; 0.00]
Rho($\rho\rho$)[Robust std. Err.]	-------	-0.984[0.052]		0.064[0.038]		0.069[0.030]	0.071[0.030]
Wald test indep. ρ ρ =0[df ;p-value]	-------	2.21[1; 0.1368]		-------		-------	-------
Wald test exog. chi2[df ;p-value]	-------	-------		2.75[1; 0.0973]		5.22[1; 0.022]	5.44[1; 0.019]

Source: Author's calculation using the 2014 DRC's DHS data. Note: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses.

According to the IVProbit estimates (Equation 5 of Table 5), economic well-being reduces significantly the risk of being underweight by -46.8%, controlling for other covariates. This indicates that correcting for endogeneity increases significantly the marginal effect of economic well-being by 13.3% compared to the Probit estimate (Equation 1) and by 20.8% compared to the Heckman model estimate (Equation 3). The reduced form of economic well-being determinants in Equation 4 of Table 5 presents evidence that the distance (in kilometres) to access a public health centre and the time taken to reach the nearest water source are individually and jointly significant in explaining household economic well-being. In fact, the distance to access a public health centre has a negative influence on the household economic well-being indicator, but the time taken to reach the nearest water source has a positive influence. By considering distance as a shadow price, the negative influence could measure the opportunity cost of accessing the public goods, and it seem that the price is negatively associated with the demand for services. Therefore, this result is consistent with the microeconomic theory of demand. The partial R-squared on excluded instruments is 0.4249 and the F statistic on excluded instruments of 4494 (p-value = 0.0000) are indications that the two identifying variables are jointly significant. When the control function approach is used without the interaction term, which implies IVProbit and accounting for potential sample selection bias via the inverse of the Mills ratio, the marginal effect of economic well-being increases from -0.335 (Equation 1) to -0.465 (Equation 6), a 13 point-variation relative to the Probit estimate, but there is no significant change relative to the IVProbit estimate of Equation 5.

In addition, accounting for the possibility of non-linear interaction between economic well-being and unobservable variables further downgrades the economic well-being marginal effect to 0.408, which is still more significant than the Probit estimate. As the interaction term (economic well-being $\times\times$ its residuals) is statistically significant, the IVProbit estimate of the marginal effect of household economic well-being in the pooled sample is biased upwards. The marginal effect on the reduced form of the economic well-being residual (Equation 6) is statistically significant at the 10% level of significance, but the inverse of the Mills ratio is not significant, suggesting that sample selection bias is no longer a problem in the pooled sample. The control function approach is therefore interesting because the estimated marginal effects of child health production technology under this specification constitute an improvement to the IVProbit estimates. As the interaction term is statistically highly significant, the indication is that household economic well-being is endogenous to child health. The control function modelling has an advantage over other modelling approaches because it is capable of removing the structural parameters of most potential econometric problems, notably endogeneity, sample selection bias, and heterogeneity of unobservable variables from the endogenous variable (Mwabu, 2008).

Examining the different econometric specifications of the structural health production function, it is observed that there is no evidence of any gender bias against a girl child. Instead, the effect is against a boy child as boys have a high rate of being

underweight, which translates with high statistical significance into the likelihood of boys being more underweight than girls. For example, from Equation 7 in Table 5, we note that boys have 5.2% more risk of being underweight compared to girl children. Rather than treating the sample as a homogenous group, empirically disaggregating results by gender is important for guiding public health interventions. However, from the statistic results we have observed that the prevalence of being underweight varies a lot according to household economic well-being status and there is a gap in economic well-being by gender of household head.

4.2.2 Control Function Estimation of Child Health Production Function by Gender

Table 6 presents control function estimates of the structural parameters of underweight children by gender of the household head. For the male sub-sample (Equations 2 and 5), the effect of the economic well-being indicator on the risk (probability) of a child being underweight is significant and negative; a finding that is consistent with the previous evidence provided in Table 5. However, the female household head sub-sample depicts a negative but non-significant relationship between economic status of the household and risk of a child being underweight (Equations 3 and 6). In particular, the male household head sub-sample captures the effects of economic household status on a child being underweight that are significantly in excess of those depicted by the pooled sample in Table 6. These results suggest a spill-over effect of economic well-being that influences households headed by males to adopt more useful health behaviour than their female counterparts. This result is probable as females who head households tend to grapple with a wide range of issues on their own as they are generally single-parents. Meanwhile, male household heads usually have their spouses present when confronted with family issues and when seeking quality information on health care and nutrition that may enhance the child's health status. The economic well-being indicator effect on a child being underweight depicted in the male sub-sample could be perceived as including the unobserved contribution of a female.

All the empirical specifications generate a negative and highly significant effect of a household economic well-being indicator on a child being underweight. Thus, our findings highlight that the household economic well-being indicator is a significant determinant of child health, which is consistent with the literature. For example, Chalasani and Rutstein (2014) found that the household wealth indicator constructed from the possession of assets and housing is an important determinant of the reduction of malnutrition measured by weight-for-age among children under five in both the rural and urban regions.

Regarding the effect of sociodemographic variables, from the pooled sample (Tables 5 and 6) it can be seen that the pattern of marginal effect of child age in all specifications has an inverted U-shape, indicating that younger children are more likely than older children to be malnourished. Birth weight appears to be a significant determinant of the reduction of underweight of children under five. For example, from

Equation 7 in Table 5 (or Equation 6 in Table 6) it is evident that a one-unit increase in child birth weight implies a decrease of the risk of the child being underweight of 6.1%.

Table 6: Control function approach – estimation of child health production function by

Variables	Linear			Non-linear		
	All (1)	Male (2)	Female (3)	All (4)	Male (5)	Female (6)
Economic well-being indicator	-0.465*** (0.145)	-0.470*** (0.161)	-0.229 (0.314)	-0.408*** (0.154)	-0.425** (0.172)	-0.173 (0.325)
Child gender	0.052*** (0.016)	0.049*** (0.018)	0.058 (0.037)	0.052*** (0.016)	0.049*** (0.018)	0.059 (0.037)
Child age	0.007*** (0.002)	0.007*** (0.002)	0.007 (0.005)	0.007*** (0.002)	0.007*** (0.002)	0.007 (0.005)
Child age squared/10	-0.001 (0.000)	-0.001* (0.000)	-0.000 (0.001)	-0.000 (0.000)	-0.001* (0.000)	-0.000 (0.001)
Child is twin	0.086* (0.048)	0.118** (0.053)	-0.143 (0.119)	0.084* (0.048)	0.117** (0.053)	-0.145 (0.119)
Child birth size	-0.030 (0.027)	-0.037 (0.053)	0.005 (0.062)	-0.031 (0.027)	-0.037 (0.030)	0.004 (0.062)
Child birth weight	-0.064*** (0.013)	-0.066*** (0.015)	-0.060** (0.027)	-0.065*** (0.013)	-0.067*** (0.015)	-0.061** (0.027)
Mother's age	-0.008 (0.009)	-0.009 (0.011)	-0.003 (0.021)	-0.008 (0.009)	-0.009 (0.011)	-0.003 (0.021)
Mother's age squared/10	0.001 (0.001)	0.001 (0.002)	0.000 (0.003)	0.001 (0.001)	0.001 (0.002)	0.000 (0.003)
Mother's BMI	-0.014*** (0.004)	-0.012*** (0.004)	-0.026*** (0.009)	-0.014*** (0.004)	-0.013*** (0.004)	-0.026*** (0.009)
Mother's education	0.000 (0.004)	0.001 (0.004)	-0.005 (0.008)	0.000 (0.004)	0.001 (0.004)	-0.005 (0.008)
Mother's employment status	-0.004 (0.019)	0.002 (0.022)	-0.001 (0.040)	-0.004 (0.019)	0.002 (0.022)	-0.010 (0.040)
Household head's age in years	-0.004 (0.005)	0.001 (0.006)	-0.019* (0.011)	-0.004 (0.005)	0.001 (0.006)	-0.018 (0.011)
Household head's age squared/10	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.001 (0.001)
Household size	0.009* (0.006)	0.006 (0.005)	0.030** (0.014)	0.009* (0.005)	0.006 (0.005)	0.029** (0.014)
Household head is Catholic	-0.037 (0.033)	-0.036 (0.038)	-0.051 (0.066)	-0.038 (0.033)	-0.036 (0.038)	-0.056 (0.066)
Household head is Protestant	-0.048 (0.034)	-0.048 (0.039)	-0.085 (0.070)	-0.049 (0.034)	-0.048 (0.039)	-0.089 (0.070)

Household head is other Christian	-0.017 (0.033)	-0.030 (0.039)	-0.003 (0.066)	-0.016 (0.033)	-0.029 (0.039)	-0.001 (0.066)
Controls for unobservable variables						
Predicted residuals of economic well-being	0.190* (0.158)	0.189 (0.175)	-0.057 (0.353)	0.386 (0.240)	0.332 (0.264)	0.261 (0.591)
Economic well-being x its residuals	-------	-------	-------	-0.626** (0.576)	-0.471 (0.636)	-0.978 (1.473)
Inverse of Mills ratio	0.149 (0.557)	0.017 (0.621)	1.766 (1.405)	0.158 (0.557)	0.023 (0.622)	1.710 (1.406)
Number of obs.	4368	3196	1172	4368	3196	1172
Wald chi2[df ; p-value]	203.12 [2 1 ; 0.000]	155.84 [2 1 ; 0.000]	62.21 [2 1 ; 0.000]	202.94 [2 2 ; 0.000]	155.58 [2 2 ; 0.000]	62.21 [2 2 ; 0.0000]
Rho()[Robust std. Err.]	0.069 [0.030]	0.029 [0.032]	0.005 [0.066]	0.071 [0.030]	0.029 [0.033]	0.002 [0.066]
Wald test of exogeneity chi2 [df ; p-value]	5.22 [1 ; 0.0223]	0.76 [1; 0.3826]	0.00 [1; 0.943]	5.44 [1; 0.0197	0.76 [1 ; 0.3845]	0.00 [1; 0.966]

gender – ME

Source: Author's calculation using the 2014 DRC's DHS data. Note: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses.

4.2.3 Robustness Check

To check the robustness of the effect of economic well-being, the outcome variable is modified in order to capture the individual effects of economic well-being variables. From a strictly empirical point of view, this is an important issue for policy formulation as we examine which of the variables of household economic well-being is the most significant in the child health production function. The results from the Probit estimation are given in Table 7. The equation from the pooled sample suggests that the use of unshared and improved toilets, and improved floor material and electricity are significant in the child health production function. The possession of a radio is significant in the equation of the male sub-sample. The signs of these variables are all negative, suggesting that the economic well-being variables contribute to reducing the risk of a child being underweight. These results confirm the robustness of the positive effect of

household economic well-being on child health highlighted in this study.

Table 7: Estimation of individual effects of economic well-being variables on child health

Variables	All	Male	Female
Economic well-being variables			
Household has livestock	-0.016 (0.012)	-0.021 (0.014)	-0.004 (0.026)
Household uses water from improved source	-0.018 (0.013)	-0.015 (0.015)	-0.035 (0.029)
Household uses unshared and improved toilet	-0.033** (0.013)	-0.029** (0.015)	-0.049* (0.029)
Household has improved floor material	-0.052** (0.024)	-0.052* (0.027)	-0.056 (0.048)
Household has electricity	-0.068** (0.027)	-0.074** (0.031)	-0.061 (0.058)
Household has radio	-0.023 (0.013)	-0.032** (0.014)	0.018 (0.031)
Household has at least a mobile phone	0.004 (0.013)	0.015 (0.014)	-0.041 (0.028)
Sociodemographic variables			
Child gender	0.062*** (0.012)	0.060*** (0.014)	0.076*** (0.026)
Child age	0.007*** (0.001)	0.006 (0.002)	0.010*** (0.003)
Child age squared/10	-0.000* (0.000)	-0.000*** (0.000)	-0.001* (0.001)
Child is twin	0.155*** (0.030)	0.184*** (0.034)	0.049 (0.069)
Child birth size	-0.036* (0.020)	-0.035 (0.023)	-0.034 (0.044)
Child birth weight	-0.054*** (0.010)	-0.057*** (0.011)	-0.044** (0.021)
Mother's age	-0.009 (0.007)	-0.011 (0.008)	-0.003 (0.015)
Mother's age squared/10	0.001 (0.001)	0.002 (0.001)	-0.000 (0.002)
Mother's BMI	-0.013*** (0.002)	-0.012*** (0.002)	-0.017*** (0.004)
Mother's education	-0.005*** (0.002)	-0.004* (0.002)	-0.009** (0.004)
Mother's employment status	-0.002 (0.014)	0.007 (0.016)	-0.022 (0.031)
Household head's age in years	0.001 (0.003)	0.003 (0.004)	0.000 (0.006)

Household head's age squared/10	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.001)
Household size	0.005* (0.003)	0.003 (0.003)	0.011* (0.001)
Household head is Catholic	0.001 (0.026)	0.000 (0.030)	-0.009 (0.051)
Household head is Protestant	-0.013 (0.026)	-0.017 (0.030)	-0.020 (0.051)
Household head is other Christian	-0.000 (0.025)	-0.011 (0.030)	0.021 (0.049)
Number of obs.	4368	3196	1172
LR chi2 chi2[df ; p-value]	393.77 [25 ; 0.0000]	307.05 [2 5 ; 0.0000]	114.06 [25 ; 0.0000]

Source: Author's calculation using the 2014 DRC's DHS data. Note: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses.

5.0 Conclusion and Public Policy Implications

This study attempted to establish an empirical link between household economic well-being and child health using the DR Congo's Demographic and Health Survey data. The effect of household economic well-being on child health was also estimated and gender disparities in spill-over effects were examined. A series of econometric estimation methods were used and the control function approach emerged as the most appropriate strategy as it concurrently excludes structural parameters from endogeneity, sample selection and heterogeneity of unobservable variables. The results suggested a significant and positive effect of household economic well-being on child health. Correcting for endogeneity and taking into account the unobserved heterogeneity significantly increases the magnitude of the effect. The magnitude of the effect varied by gender, as households headed by males were seemingly more likely to undertake better health behaviours that would improve health inputs than their female counterparts. In the context of DR Congo, female-headed households are often single parents, therefore the economic well-being effect on child health depicted in the male sub-sample is considered to include the unobserved contribution of women. Moreover, among the sociodemographic variables it was noted that younger children are more likely than older children to be underweight, and that birth weight remains a significant determinant of children's health under five years of age. These results have implications for state intervention in the promotion of social facilities (child care centres and health centres) as an important factor for the allocation of women's time to paid activities in the labour market as a means of enhancing income growth and household economic well-being, which in turn will improve child health. These results also have implications for public intervention in the creation and promotion of employment opportunities in all sectors, particularly in the agricultural sector. By doing this, the income generated by employment could support the accumulation of household assets and the improvement of housing and habitat conditions and good living conditions, which will result in the improvement of children's health.

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Mission

To strengthen local capacity for conducting independent, rigorous inquiry into the problems facing the management of economies in sub-Saharan Africa.

The mission rests on two basic premises: that development is more likely to occur where there is sustained sound management of the economy, and that such management is more likely to happen where there is an active, well-informed group of locally based professional economists to conduct policy-relevant research.

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