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Infant and Young Child Feeding (IYCF) Practices and Children's Nutritional Status in Democratic Republic of Congo (DRC): Evidence from Demographic and Health Surveys

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Infant and Young Child Feeding (IYCF) Practices and Children's Nutritional Status in Democratic Republic of Congo (DRC): Evidence from Demographic and Health Surveys

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Abstract

This paper uses a pooled dataset of the 2007 and 2014 Demographic and Health Surveys (DHS) to establish the empirical linkages between infant and young child feeding (IYCF) practices and children's nutritional status in Democratic Republic of Congo (DRC). The paper examines all the recommended dimensions of child feeding and builds an index from variables related to breastfeeding, use of bottle-feeding, minimum dietary diversity and number of times child ate solid, semi-solid or soft foods. A series of descriptive analyses and survey-based econometric regressions are carried out while controlling for endogeneity and heterogeneity. The key finding is that infant and young child feeding practices are an important and significant determinant of children's nutritional status as measured by the height-for-age z-score and the probability of stunting. In particular, an increase in the IYCF practices index by 1 unit increases by 0.47 standard score in the height-for-age z-score while it reduces the probability of child stunting by -0.5 controlling for other covariates. The paper recommends to the DRC's Ministry of public health to reinforce the parent's education, especially mothers of children, on the importance of infant and young child feeding practices for the nutrition of their children.

Keywords: Feeding practices, Children's nutritional outcomes, Instrumental variable, Control functions approach, Democratic Republic of Congo.

1. Introduction

In many Sub-Saharan Africa (SSA) countries child malnutrition is widely considered as a serious problem for economic growth and development (Büttner et al, 2023; Gillani et al, 2022; Vollmer et al, 2014; Olack, 2011, United Nations Children's Fund [UNICEF], 1991). In effect, malnutrition in childhood is associated with high risk of child mortality and long-term consequences, particularly for human capital development, economic productivity and national development overall. In the DRC, child malnutrition is an issue of major concern. According to the most recent data, nearly 2 million children are suffering from severe acute malnutrition (SAM), which accounts for 12 per cent of SAM cases in the world (United States Agency for International Development [USAID], 2017). In addition, over six million children under five (43 per cent) suffer from chronic malnutrition (Ministère du Plan et al. 2014). Although the proportion of children under 5 who are stunted (chronic malnutrition) has dropped from 46 per cent in 2007 to 43 per cent in 2014, it is still considered very high by the World Health Organization (WHO) and the UNICEF. Inadequate Infant and Young Child Feeding (IYCF) practices contribute to nutrition problems of under five children in the DRC. In accordance with WHO (2008), appropriate IYCF practices include exclusive breastfeeding in the first 6 months of life, continued breastfeeding through age 2, introduction of solid and semi-solid foods at age 6 months, and gradual increases in the amount of food given and frequency of feeding as the child gets older (WHO, 2008). But in the DRC, only 48 per cent of children 0–5 months are exclusively breastfed and only 22 per cent are still exclusively breastfed at 4–5 months, and just nine per cent receive a minimum acceptable diet (Ministère du Plan et al. 2014).

Several studies on children's nutritional status in SSA have described prevalence of malnutrition among under-five children and analysed socioeconomic, demographic and environmental factors associated with children's malnutrition (Mboutchouang et al, 2023; Mwisha-Kasiwa, 2018; Akombi et al. 2017; Kandala et al. 2011; Olack, 2011; Kabubo-Mariara et al. 2008; Fotso, 2007; Pongou, 2006; Sahn and Stifel 2002; Madise, 1999). Although the UNICEF nutrition framework places inadequate dietary intake and inadequate care as immediate drivers of malnutrition (Webb, 2013; UNICEF, 1991), little is known about the links between Infant and Young Child Feeding (IYCF) practices and child's nutritional status in SSA, particularly in the DRC. This study aims to investigate the impact of infant and young child feeding practices as a proxy of diet and care toward children on children's nutritional status. The novelty of the study lies in three key contributions: firstly, to the best of our knowledge, this study presents a first attempt to link infant and young child feeding practices to child nutrition using the most recent DRC's DHS data and addresses not only the height-for-age (HAZ) but also the probability (or risk) of stunting as one of the indicators of child nutrition. The rare previous literatures in DRC have addressed socioeconomic and environmental determinants of child nutritional status and have used one or more anthropometric indices to measure child nutritional status (Kismul et al. 2018; Kandala et al. 2011; Emina et al. 2011).

From a policy formulation point of view, it is of great importance to examine the probability of stunting since then there could be threshold effects around a -2 height-for-age z-score than anywhere else in the child HAZ distribution. The argument is that a HAZ comprised between -2 and 2, do not matter for policy but HAZ below -2 matters because it is associated with increased risk of mortality and poorer cognitive development. A HAZ more than 2, is also an indication of overweight and obesity that has bad consequence on health. Secondly, the previous most studies in the literature have focused on children under five overall. In this study we are interested in children of 6-23 months of age. The rational of choosing this age range is that infant and young child feeding during the first two years of life is a key period to improve child survival, healthy, growth and development (WHO, 2008). Appropriate feeding practices during this critical period can decrease morbidity, mortality, risk of chronic disease, and developmental delays (Temesgen, 2018; WHO, 2008; Cuanalo De La Cerda, 2007).

Thirdly, most previous research in this area have largely neglected the problem of endogeneity caused by the nature of the relationship between child feeding practices and child nutritional status. Concretely, child feeding practices variable may be endogenous in the child nutritional model, i.e., it may be determined by a set of factors that also determine the nutritional outcome. For example, maternal education and household socioeconomic factors may influence both feeding practices and children's nutritional status. Moreover, it may exist a bi-causal relationship between child feeding practices and child nutritional status. This bi-causal relationship is likely to arise because parents may adopt different feeding practices depending on the current nutritional status of the child. In this instance, the direction of causality could also run from child nutrition to feeding practices. We address the potential problem of endogeneity using an appropriate econometric strategy based on the instrumental variable method and the control function approach. Since this study is in line with the international community's commitment to end all forms of malnutrition by 2030 as part of the second Sustainable Development Goal (SDG), it has therefore potential to contribute to the formulation of nutrition policy that could allow DRC to be on the path of achieving the SDGs.

The rest of the paper is organised as follows. The next section deals with the analytical and conceptual frameworks, section 3 presents the data and methods while section 4 presents and discusses the results and section 5 concludes.

2. Analytical framework

2.1. Theoretical model

The theory of human capital investment and the household production model (Strauss and Thomas, 1995; Becker, 1965), have served as theoretical frameworks for several studies on child health and nutrition (Mwabu, 2009; Kabubo-Mariara et al. 2008; Rosenzweig and Schultz, 1982). The basic idea is that households allocate time and goods to produce commodities that yield utility; some of these commodities are purchased in the market, some consumed at home and some for which there is no market at all. Within this framework, a household faces preferences that can be characterised by the following utility function:

$$U = u(X, L) \qquad (1)$$

Where X represents a vector of commodities that household can consume and L a vector of leisure. The production function for the consumption good depends on a vector of household input supplies. Given this production function and a budget constraint, the household chooses the optimal consumption bundle of inputs. Therefore, the model can be modified to a model of human capital outcomes (such as child nutritional status) by relaxing the assumption of perfect substitutability between home produced and market goods (Strauss and Thomas, 1995). The rational is that, in reality, most human capital outcomes cannot be purchased in the market and the household production framework also lenders itself to the integration of biological, demographic and economic considerations.

Since then, child nutrition can be thought as being generated by a biological production function in which a number of input allocations such as nutrient intake and general care result from household decisions. Households therefore choose to maximise child nutrition given the resources and information constraints they face. To model child nutrition, Equation (1) can be modified by including child nutrition (N) as follows:

$$U = u(X, L, N) \qquad (2)$$

Child nutritional production is embedded in a utility-maximising behaviour of the household.

The corresponding budget constraint can also be modified to include inputs into a child nutritional production function and the resulting constrained utility function solved for the optimal quantities of child nutrition supplied to the market. In light of the literature (Mwabu, 2009; Strauss and Thomas 1995), the reduced form of nutritional production function for the child i can be represented by the following equation:

$$N_i = f\left(F_i, x_j, \varepsilon_i\right) \quad (3)$$

Where N is the child nutritional status, measured by the HAZ and the likelihood of being stunted; F is the household (or mother) feeding practices; x is a vector of control variables including child, household and community characteristics; ε is the child specific disturbance term. Through the household budget constraint, change in price of commodities that household can consume affect child nutrition outcomes. Hence, for policy orientation we need to know parameters of both the child nutrition production technology and the associated nutrition input demand to predict nutrition effects of changes in input prices. To that end, nutrition production and input demand parameters must be estimated simultaneously. Such estimation is complicated by the need to identify input demand from nutrition production technology (Mwabu, 2009). In our case, the estimation is further complicated because of the suspicion of endogeneity.

2.2. Model estimation and strategy of identification

Estimating Equation 3 with ordinary least square (OLS) when feeding practices is exogenous, i.e., when feeding practices is uncorrelated with error terms, could yield consistent estimate. However, because of the bi-causal relationship between the two phenomenon and due to unobservable characteristics, such as particular talents or skills, which could influence as well as child feeding practices and child nutritional outcomes, feeding practices may not be exogenous. Feeding practices are likely to Cluster. In other words, it is possible that a mother who initiates breastfeeding at birth and who exclusively breastfeeds for 6 months will also be more aware of (or more likely to seek expert information about) recommended optimal complementary feeding. In such a configuration, feeding practices could be endogenous in the children’s nutritional production function.

To address this issue of endogeneity, we estimate the model in a system of two equations (feeding practices and child nutritional outcomes) in which the first step is to find valid instruments for the feeding practices as endogenous explanatory variable. Indeed, the instruments serve as variables of identification and exclusion restrictions in the model. For that end, we use two community-level variables as instruments: the cluster rate of female unemployment and the cluster average time spent in minutes to the nearest water source. The economic rationale for the validity of these instruments is that the level of female unemployment rates and the distance to water source, may depend on socio-economic conditions and local infrastructure, which are assumed to be exogenous to households. In this way, both variables can be used as instrumental variables because they would be correlated with mother feeding practices without being correlated with unobservable determinants of child nutritional status. For example, higher local female unemployment rates could make it hard for women to access jobs in formal sector so that women will be more likely to work in the informal sector in which quality of employment is poor; and thus, jobs in that sector are incompatible with good child feeding practices. Since then, infant and young child feeding practices will be influenced by the women employment status. The sample in our dataset contains 540 clusters, so this instrument has the statistical variation needed to produce effective results.

The choice of the second instrument is justified in terms of opportunity cost of the time spent in collecting water by the mothers of children. The explanation is that, when women allocate an amount of time to the collection of water, they cannot in the meantime dedicate the same amount to the feeding activities of their children. Since time spent to collect water is used as a proxy for the fixed distance that each woman must travel from her home to the nearest water source, a correlation between this variable and child feeding practices is possible; but without a direct influence on the child nutritional outcomes. The longer the time spent in water fetching, the less is the mother's time allocated to child feeding activities. We therefore adopt the maximum likelihood and the linear regression as methods of estimation. In particular, the instrumental variables procedure followed by the control function approach are used. In keeping with Wooldridge (2002) and Mwabu (2009), our estimation approach may be summarized as follows:

$$N = x_1\delta_n + \varphi F + \varepsilon_1 \qquad (4)$$

$$F = x\delta_f + \varepsilon_2 \qquad (5)$$

Where N and F are child nutrition and feeding practices respectively; x_1 is a vector of exogenous covariates such as child, household and community characteristics, x an exogenous set of covariates, comprising $x_1$explanatory variables that also belong to the child nutrition production function (outcome equation), plus a vector of instruments, x_2, that affect the feeding practices, F, but have no direct influence on child nutrition, N; and δ, $\varphi,$ and ε are parameters to be estimated, and error terms, respectively. While Equation 4 is the structural equation of interest, Equation 5 is the linear projection of the potential endogenous variable, F, on all the exogenous variables, $x = x_1 + x_2$, that is, a reduced form linear probability model of infant and young children feeding practices of the mother/household. To account simultaneously for potential endogeneity and non-linear interactions of unobservable variables with the observed regressors specified in the nutrition function, Equation 4 can be extended as follows (Mwabu, 2009):

$$N = x_1\delta_n + \varphi F + \alpha\hat{\varepsilon}_2 + \gamma(\hat{\varepsilon}_2 * F) + u_1 \qquad (6)$$

Where, $\hat{\varepsilon}_2$ is fitted residual of F, derived from the reduced form linear probability model of feeding practices (Equation 4); $(\hat{\varepsilon}_2 * F)$ is interaction of the fitted feeding practices residual with the actual value of feeding practices; u_1 is a composite error term comprising ε_1 and the unpredicted part of ε_2, under the assumption that $\varepsilon_1 \sim N(0, \sigma)$; and δ, φ, α and γ are parameters to be estimated. The exclusion restrictions are imposed on Equation 6 because the vector of instruments, x_2 (for feeding practices, F), is absent. The terms $\hat{\varepsilon}_2$ and $(\hat{\varepsilon}_2 * F)$ in Equation 6 are the control function variables because they control for the effects of unobserved factors that would otherwise contaminate the estimates of structural parameters. The fitted reduced form feeding practices residual, $\hat{\varepsilon}_2$, serves as the control for unobservable variables that correlate with F. In particular, if an unobserved variable is linear in $\hat{\varepsilon}_2$, it is only the constant term that is affected by the unobservable. The interaction term, $(\hat{\varepsilon}_2 * F)$, controls for the effects of neglected non-linear interactions of unobservable variables with feeding practices.

However, the Instrumental Variable (IV) estimates are unbiased and consistent only when: (a) the expected value of the interaction between feeding practices and its residual $(\hat{\varepsilon}_2 * F)$ is zero or the correlation is linear and (b) there is no sample selection problem. If the correlation is non-linear and/or sample selection is a problem, then the control function approach is required and the inclusion of the interaction term, $(\hat{\varepsilon}_2 * F)$, and inverse of the mills ratio in Equation 6 purifies the estimated coefficients of the effects of unobservable variables and potential non-randomness, respectively (see Mwabu, 2009). Our Equation 6 does not take into account the potential sample selection bias. The children anthropometric data were collected directly by measuring the height, weight. In such a configuration there is no reason to assume for a sample selection of our dependent variable, namely the height-for-age z-score.

2.3. Data

The analyses in this study are based on a pooled data set from the DRC's 2007 and 2014 Demographic and Health Surveys (DHS) conducted by the National Ministry of Planning in collaboration of the ministry of Public Health and with the partnership of Measure DHS, ICF International and other UN and International donors (Ministère du Plan et al., 2014). Although the two surveys differ in some respects, they are comparable on several criteria. Both surveys used a multi-stage cluster sampling survey. In accordance with the DRC's administrative division, the 2007 survey has divided the country into 11 sampling domains while the 2014 survey took into account 26 provinces in accordance with the new administrative division. These domains were further stratified into urban and rural areas. In urban areas, neighborhoods were sampled from cities and towns whereas for rural areas villages and chiefdoms were sampled. Subsequently a fixed number of households were chosen from each of the selected clusters. In the 2014 survey, a total of 18171 households (5442 from 161 clusters in urban and 12729 from 379 clusters in rural) were successfully interviewed. From these households, 18827 women of 15-49 years of age (6827 in urban and 12000 in rural) were interviewed. The 2007 survey covered 8886 households (3697 in urban and 5189 in rural), of which 9995 women aged 15-49 from 300 clusters were successfully interviewed. The two surveys have collected data on mother's child feeding practices and nutritional status for children under 5 in the selected households. In total, a sample of 9030 children under five of age in the 2014 survey, were considered for nutrition indicators and among them, 4873 children aged 6-23 months. The 2007 survey however has considered a sample of 8999 children under five and among them, 3951 were aged 6-23 months. The information on the feeding practices were collected for young children aged 6-23 months who live with their mothers and who are adequately fed during the previous 24 hours. Finally, the number of observation is 33360 in the poled dataset.

2.4. Measure and definition of key variables

2.4.1. Dependent variables

We have two dependent variables: the height-for-age z-score (HAZ), a continuous variable and the stunting, a dichotomous variable. The HAZ is available in DHS's dataset and it's calculated following the 2006 WHO Child Growth Standards. The child stunting is defined as height-for-age z-score (HAZ) below -2 standard deviations. Hence, the stunting variable was constructed from the HAZ. Our measure of nutritional status is most appropriate in the context of the DRC where 43% of children under five suffer from chronic malnutrition (Ministère du Plan et al., 2014).

2.4.2. Infant and Young Child Feeding practices

The Infant and Young Child Feeding (IYCF) practices is our independent variable of interest. However, let mention that child feeding, which includes breastfeeding and complementary feeding practices, is a multidimensional concept. It comprises notably, the type, the quality, the texture, the nutrient density, the frequency of feeding and the diversity of the diet. Infant and Young Child Feeding practices are also age-specific.

In the literature, most studies on child feeding practices have focused on only one or two dimensions at a time (Srivastava and Sandhu, 2006). These studies, while valuable for evaluating the role of individual practices, do not allow an examination of the impact of child feeding practices as a whole on children's health and nutritional outcomes. In this study, we construct a composite index of child feeding practices. The main advantage of this approach is that, the composite index allows construction of one variable representing various dimensions of feeding practices. To build the IYCF practices index, we follow the WHO's IYCF guidelines (as summarized in Figure 1), in the sense that they are designed to measure dietary practices for both breastfed and non-breastfed children aged 6-23 months.

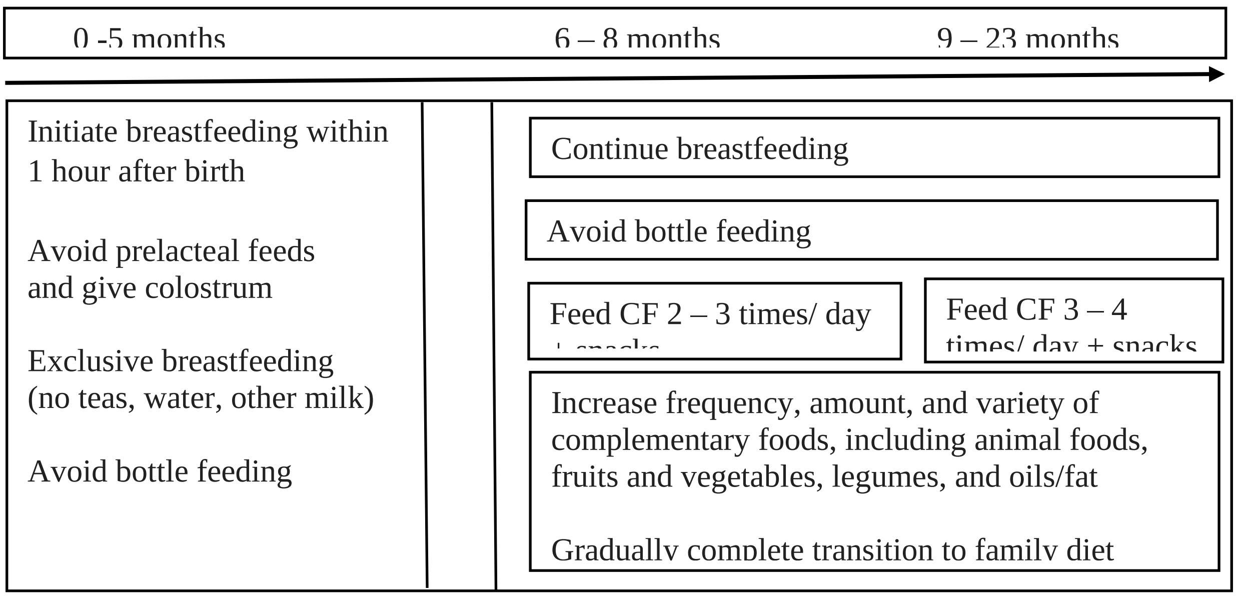

Figure 1: Continuum of IYCF. CF: complementary feeding.

Optimal feeding practices are defined for two different age groups (see Ministère du Plan et al., 2014): 6–9 months (breast-feeding plus gradual introduction of complementary foods); 9–23 months (same as 6–9 months, but increasing the amount and frequency of complementary feeding and gradual transition to the family diet and focus on dietary quality). The following variables are used in the index creation: breastfeeding mother is currently breast-feeding the child or not); use of baby bottles in the previous 24 h (yes/no); dietary diversity (whether or not the child received selected food groups (minimum dietary diversity) in the previous 24 h); feeding frequency (how many times the child was offered solid or semisolid foods in the previous 24 h). The list of variables and the scores used to create the child feeding index for the different age groups are presented in Table 3. The general scoring system consists in assigning a score of "0" for a potentially harmful practice and a positive score of "1" for a positive practice. Practices are considered positive or negative on the basis of child feeding recommendations and available scientific evidence about their benefits or risks (WHO, 1995). The dataset used in the analysis contains information on food items that were used to calculate the indicator. We categorized these food items into seven food groups based on the WHO's IYCF guideline (WHO, 2010). These food groups are: (i) grains, roots, and tubers; (ii) legumes and nuts; (iii) flesh foods (meats, fish, poultry and liver/organ meat); (iv) eggs; (v) vitamin A rich fruits and vegetables; (vi) dairy products (milk, yogurt, cheese); (vii) other fruits and vegetables. If a child consumed at least one food item from a food group, the group was assigned a value of one for that child. The group scores are then summed to obtain the dietary diversity score, which ranges from zero to seven, where zero represents non-consumption of the food items and seven represents the highest level of diet diversification.

2.4.3. Control and instrumental variables

We also have control variables including a set of child characteristics (age, gender, birth size, birth weight, and twin birth), maternal characteristics (age, educational attainment, employment status), household characteristics (household size, gender of the household head, place of residence) and community and environmental characteristics (proportion of households with improved and unshared toilets, proportion of households with piped water). As said above, we instrument feeding practices using exogenous variables (cluster average rate of female unemployment and cluster average time in minutes to get to the nearest water source). We finally have as control of unobservable, the predicted residuals of feeding practices, the interaction between feeding practices and its residuals.

3. Results and discussion

We first report the descriptive statistics. Second, we report estimates of the effects of IYCF practices on the child nutrition production using alternative modelling strategies including the control function approach.

3.1. Descriptive statistics

3.1.1. Dietary diversity of children aged 6-23 months

As mention above, IYCF practices include the gradual introduction of solid and semi-solid foods from the age of 6 months, increasing as well as the quantity, the variety of foods and the frequency of feeding as the child gets older. Therefore, before describing the IYCF index, we first examine trends in complementary food consumption and calculate the dietary diversity score.

- **Trends in dietary intake**

Table 1 presents descriptive statistics of children's dietary intake. One can observe that foods from the group of grain, roots and tubers and foods from the group of vitamin A rich fruits and vegetables are the most consumed by children from our sample. In fact, 57.2% of children consumed at least one of food group of grains, roots and tubers during the last 24 hours preceding the survey and 56.7% have consumed foods from the group of vitamin A rich fruits and vegetables. From these statistics, we note that the proportions of children who consumed these foods are low, under 50% for the most of them. This reflects the dietary intake deficit among children under 5 often reported in the DRC (see USAID, 2017).

Table 1: Trends in children dietary intake (Pooled sample)

Food groups and food items	DRC	Urban	Rural
Food group 1: Grains, roots, and tubers	57.2	65.7	53.3
Gave child bread, noodles, other made from grains	42.7	52.5	38.2
Gave child potatoes, cassava or other tubers	28.8	26.1	29.9
Gave child fortified baby food (cerelac, etc)	3.4	8.8	1.1
Food group 2: Legumes and nuts	16.4	20.8	14.5
Gave child food made from beans, peas, lentils, nuts	15.5	19.1	13.9
Food group 3: Dairy products	10.0	22.2	4.6
Gave child tinned, powdered or fresh milk	8.4	18.9	3.6
Gave child cheese, yogurt, other milk products	1.6	3.5	0.9
Gave child yogurt	1.1	2.3	0.6
Food group 4: Flesh foods	34.2	37.3	32.9
Gave child meat (beef, pork, lamb, chicken, etc)	10.5	12.0	9.9
Gave child liver, heart, other organs	3.0	3.6	2.7
Gave child fish or shellfish	27.0	29.1	26.2
Food group 5: Eggs	6.5	9.2	5.5
Gave child eggs	6.5	9.2	5.5
Food group 6: Vitamin A rich fruits and vegetables	56.7	58.4	56.0
Gave pumpkin, carrots, squash (yellow or orange inside)	10.1	10.0	10.1
Gave child any dark green leafy vegetables	49.4	50.0	49.1
Gave child mangoes, papayas, other vitamin A fruits	15.0	18.9	13.4
Food group 7: Other fruits and vegetables	23.1	28.4	20.7
Gave child any other fruits	23.1	28.4	20.7

Source: Author's calculation using data from DHS 2007 & 2014.

➢ Minimum dietary diversity (MDD)

To have an idea on the MDD we need to know the Dietary Diversity Score (DDS). To calculate the DDS we follow the WHO's IYCF recommendation. Table 2 presents the descriptive statistics of the DDS. About 31.9% of children in our sample have ate none of the foods in seven food groups; with 30% in urban areas and 33% in rural. We therefore note that sufficient dietary diversity, that is the consumption of a variety of foods to meet nutritional needs, is not achieved. In other words, the minimum dietary diversity (MDD) is not reached for the most part of children. As a reminder, to meet basic nutritional needs, WHO recommends a consumption of at least a minimum of four out of the seven food groups per day for children 6-23 months of age; that is called minimum dietary diversity.

Table 2: **Dietary diversity score of children 6-23 months (Pooled sample)**

Dietary diversity score (DDS)	DRC	Urban	Rural
0	31.87	29.88	32.68
1	16.35	14.28	17.19
2	22.10	18.23	23.69
3	17.17	18.23	16.73
4	8.30	11.84	6.85
5	2.96	5.02	2.11
6	0.87	1.80	0.48
7	0.39	0.72	0.25

Source: Author's calculation using data from DHS 2007 & 2014.

According to the figures in Table 2, only 12.52% of children in our sample met the minimum dietary diversity, that is, only this proportion of children ate at least four different food items of different food groups. The analysis by type of place of residence suggests a significant disparity with 19.38% in urban areas against 9.69% in rural areas; this could mean that children in urban areas are well nourished than those in rural areas.

➢ Infant and young child feeding (IYCF) practices index

The index is created on the basis of feeding recommendations for children 6–23 months as summarized below. The do this, we use the Multiple Correspondence Analysis (MCA) method. The MCA is an application of simple correspondence analysis of multinomial data coded in the form of an indicator matrix (Burt matrix). The MCA is appropriate to improve on the PCA procedure when the latter approach loses its optimal parametric estimation properties and also to provide a more powerful tool to describe the hidden structure in a set of qualitative variables (see Asselin, 2009; Kabuba-Mariara et al., 2011). Table 3 presents the descriptive statistics of the variables used in the construction of the IYCF practices index and those concerning the index as a variable. Nearly seven children of 6-23 months out of ten (67%) are breast-fed, 61% of them in urban areas and 70% in rural areas. Baby bottle use is not recommended for young children because it is most often associated with an increased risk of diseases, especially diarrheal diseases. The statistics in Table 3 show that some mothers use baby bottles. In fact, 5% of children in our sample had been bottle-fed in the 24 hours preceding the interview, this proportion is 9% in urban areas and 4% in rural areas.

Table 3: Variables and scores used to create the child feeding index for children 6–23 months

Variable and definition	Scoring	DRC	Urban	Rural
Breastfeeding (whether or not the mother is currently breast-feeding the child)	No=0; Yes=1	88.99	84.23	91.32
Use of bottle (whether or not the child has been bottle-fed in the previous 24 h)	No=1; Yes=0	5.96	9.86	4.06
Minimum dietary diversity (whether or not the child consumed at least 4/7 food groups in the previous 24 h)	No=0; Yes=1	12.95	21.16	9.44
Number of times child ate solid, semi-solid/ soft food yesterday	Continuous variable	1.76	1.76	1.76
Infant and young child feeding (IYCF) practices index		0.7705	0.7428	0.7840

Source: Author's calculation using data from DHS-2007 & 2014.

Regarding the minimum dietary diversity (MDD), it can be noted that about 13% of the children included in our sample have met the WHO recommendation on infant and young child feeding. However, we observe that the proportion of children who ate at least four food groups, as recommended by WHO, is high (19%) in urban areas compared to rural areas (10%). The average number of times children ate solid, semi-solid and soft food in the previous 24 hours is 1.68; this value is close to the recommended value of 2 times for children 6-9 months, whereas it should be 3 times for those aged 9-23 months. In line with the statistics of Table 3, we also note that rural mothers reported best practices of breastfeeding and baby bottle use compared to those in urban areas. As a result, the IYCF practices index in rural areas is high (0.784) compared to 0.743 in urban areas.

3.1.2. Description of variables short-listed for regression analysis

Table 4 displays summary statistics of variables short-listed for regression analysis. About 40% of children aged 6-23 months in the pooled sample are stunted and the average height-for-age is -1.1, which is above the poverty line of -2 z-scores. About 80 per cent of households are headed by men and 30 per cent of households are urban. On the average, children captured in our sample are aged about 11 months and slightly over 50 per cent of them are girls. We also note that 13% of children of 6-23 months were small at their birth and 4% had a low birth weight. About 72 per cent of women are employed, against 28 per cent who are not employed. Moreover, 74% of women have delivered in a health facility, against 26% who have delivered at their home. Since the use of antenatal care is used as a proxy for the use of preventive health care, the proportion of women who gave birth at home reflects the difficulty of accessing maternal health care. Moreover, only 47 per cent of households have improved and unshared toilets and only about 38 per cent have access to piped water.

Table 4: Descriptive statistics of variables short-listed for regression analysis

Variables	2007		2014		Pooled sample	
	Mean	SD	Mean	SD	Mean	SD
Outcome variables						
HAZ (height-for-age z-score children 6-23 months)	-1.11	1.97	-1.06	1.81	-1.07	1.85
Stunting=1 if HAZ <-2 SD (children 6-23 months)	0.26	0.43	0.27	0.44	0.27	0.44
Independent variables						
IYCF practices index	0.75	0.15	0.77	0.14	0.77	0.14
Child characteristics						
Child's age in months	11.54	7.10	11.28	6.91	11.34	6.96
Child's age squared/100	1.83	1.77	1.75	1.67	1.77	1.70
Child sex=1 if male	0.50	0.50	0.50	0.49	0.50	0.49
Child’s birth size=1 if small than average	0.09	0.29	0.14	0.34	0.13	0.33
Child birth weight=1 if <2.5Kg (low)	0.05	0.21	0.04	0.21	0.04	0.21
Child is twin	0.02	0.15	0.03	0.18	0.03	0.18
Maternal/women characteristics						
Woman’s age	27.77	6.90	27.88	6.78	27.85	6.81
Woman’s age squared/100	8.19	4.11	8.23	4.00	8.22	4.02
Woman’s year of educational attainment	4.68	3.87	5.07	3.84	4.97	3.85
Woman’s employment=1 if employed	0.67	0.46	0.73	0.43	0.72	0.44
Woman gave birth in a health facility =1 if yes	0.73	0.44	0.74	0.43	0.74	0.43
Household and community characteristics						
Household size	6.89	3.11	6.78	2.92	6.81	2.97
Type of place of residence=1 if urban	0.39	0.48	0.30	0.45	0.32	0.46
Household asset index (standardized)	0.18	0.17	0.18	0.17	0.18	0.17
Household asset index squared	0.01	0.01	0.01	0.01	0.01	0.01
Household has improved & unshared toilet	0.30	0.45	0.35	0.47	0.47	0.49
Household has access to piped water	0.42	0.49	0.36	0.48	0.38	0.48
Household head=1 if male	0.84	0.36	0.78	0.41	0.79	0.40
Instrumental variables						
Cluster average time to get to water source	32.07	13.8	32.65	17.6	32.51	16.7
Cluster average rate of female unemployment	26.04	18.0	25.26	20.8	25.45	20.1
Controls for unobservable variables						
Predicted IYCF practices index residual (IYCF index minus its fitted value)	-0.01	1.75	0.004	1.66	-1.74e-16	1.68
IYCF practices index times its residual	-0.01	1.25	0.001	1.23	-2.07e-10	1.23

Source: Author’s computation using data from DHS-2007 & 2014.

The average size of households is about 7 members, which is high than the African average. The cluster average time to get to the nearest water source is about 33 minutes and the cluster average rate of female unemployment is 25%.

3.2. Econometric analysis

3.2.1. Estimates of the effects of IYCF practices on children nutritional outcome indicators

Table 5 presents estimates of the relationship between infant and young child feeding (IYCF) practices and children nutritional status as measured by the height-for-age z-score and the likelihood of stunting for children of 6-23 months, while controlling for other correlates.

Table 5 : Nutritional production function under different assumptions - Survey-based regressions

Variables & Method of estimation	Model 1 : HAZ scores		Model 2 : Probability of stunting			
	Linear regression (1)	IV 2SLS (2)	Probit (3)		IV Probit (4)	
			Coeff.	ME	Coeff.	ME
IYCF practices index	0.256***	2.429**	-0.173 ***	-0.062	-0.164***	-0.265
	(0.054)	(1.667)	(0.042)		(0.012)	
Household size	-0.005	-0.044	0.006 *	0.002	-0.019***	-0.024
	(0.003)	(0.016)	(0.003)		(0.007)	
Type of place of residence	0.077***	0.174	-0.018	-0.006	0.063***	0.054
	(0.028)	(0.058)	(0.022)		(0.022)	
Household (Hh) asset index	0.886***	0.629	-0.622 ***	-0.221	0.136	0.252
	(0.229)	(0.416)	(0.193)		(0.296)	
Hh asset index squared	0.915***	0.687	-0.324 ***	-0.027	-0.193	-0.698
	(0.707)	(0.721)	(0.488)		(0.733)	
Hh access to improved toilets	0.049**	0.129	-0.055 ***	-0.019	0.019	0.032
	(0.019)	(0.040)	(0.015)		(0.027)	
Hh has access to piped water	-0.039*	-0.069	0.028	0.010	-0.003	-0.008
	(0.023)	(0.032)	(0.018)		(0.018)	
Household head is male	-0.011	-0.004	0.001	0.001	0.017	0.004
	(0.023)	(0.031)	(0.018)		(0.015)	
Child's age in months	0.065***	0.027	0.065	0.024	0.101***	0.037
	(0.002)	(0.047)	(0.002)		(0.007)	
Child's age squared/100	-0.047***	-0.053	0.030 ***	0.011	-0.122***	0.036
	(0.001)	(0.059)	(0.001)		(0.006)	
Child is male	-0.229***	-0.217	0.168 ***	0.060	0.089*	0.075
	(0.018)	(0.025)	(0.014)		(0.049)	
Child's birth size small	-0.167***	-0.190	0.114 ***	0.041	0.054	0.030
	(0.030)	(0.039)	(0.023)		(0.041)	
Child birth weight is low	-0.266***	-0.257	0.174 ***	0.062	0.083	0.077
	(0.048)	(0.062)	(0.037)		(0.058)	
Child is of multiple birth	-0.512***	-0.370	0.300 ***	0.107	0.273 ***	0.213
	(0.054)	(0.102)	(0.041)		(0.084)	
Mother's age	-0.015	-0.061	0.003	0.001	-0.050 ***	-0.025
	(0.010)	(0.031)	(0.008)		(0.007)	
Mother's age squared	0.041**	0.153	-0.014	-0.005	0.099 ***	0.063
	(0.016)	(0.065)	(0.013)		(0.015)	
Mother's education (years)	0.034***	0.051	-0.023 ***	-0.008	0.002	0.002
	(0.003)	(0.009)	(0.002)		(0.008)	
Delivered in health facility	-0.027	-0.010	0.009	0.003	0.000	0.018
	(0.023)	(0.030)	(0.018)		(0.015)	
Constant	-1.434***	-7.568	-0.283		-0.012 ***	--------
	(0.160)	(3.008)	(0.124)		(0.438)	--------
Number of observations	33360	33360	33288		33288	--------
F-stat [Prob > F]	345[.0000]	364[.0000]	--------	--------	--------	--------
R-squared	0.1646	0.1646	--------	--------	--------	--------
Wald chi2[Prob > chi2]	3679[0.0000]		3092[0.0000]		2436[0.0000]	
Wald test of exogeneity; chi2[Prob > chi2]	--------		--------		4.34 [0.0372]	

Source: Author's computation using data from the 2007 & 2014 DHS. ***Note:*** ** p<.1; ** p<.05; *** p<.01 and (…) robust standard errors.*

All the equations are survey-based regression models that are representative of the underlying population; results have been corrected from the potential intra-cluster correlation. Equation (1) presents the linear regression results and Equation (3) presents the probit estimation of the likelihood of stunting. However, although these two equations are estimated by controlling for sample design used in the data collection procedure, they may still be contaminated by other econometric problems. To address these problems, we present in Equation (2), the 2SLS estimates that correct the structural parameters from potential endogeneity. Moreover, the Equation (4) is the IV probit estimates correcting for potential endogeneity in the stunting model.

- **The effect of IYCF practices on children HAZ scores**

The estimates indicate that by considering the IYCF practices as exogenous (Equation 1), it significantly increases the children HAZ by 0.26 standard scores, controlling for other covariates. This gives an indication that child nutrition is strongly positively associated with IYCF practices. But if the residuals from the HAZ score equation are correlated with the IYCF practices index, the estimates in Equation (1) would suffer from endogeneity bias. Since the IYCF practices is endogenous, cluster average rate of female unemployment and cluster average time in minutes to get to the nearest water source are used as identifying instruments. The reduced form model of infant and young children feeding practices (results not presented) shows evidence that the two instruments are jointly and individually significant in explaining IYCF practices. Specifically, the time taken to reach the nearest water source has a negative influence on the IYCF practices indicator, while the female unemployment rate has a positive influence. By considering time, which can give an indication on the distance separating the house and the nearest water source, as a shadow price, the negative influence could measure the opportunity cost of time to access the social infrastructure; it therefore clear that the price is negatively associated with the demand for this good. This is consistent with the microeconomic theory of demand. The partial R-squared on excluded instruments (results not presented) is 0.021 and the F statistic on excluded instruments is 8.36 (p-value = 0.0002); we can conclude that the two identifying variables are jointly significant.

According to the 2SLS estimates (Equation 2 of Table 5), IYCF practices is associated with an increase of 2.4 standard scores in the observed nutritional status. This coefficient is high than that found in the linear regression. This indicates that, by correcting for endogeneity, the coefficient on IYCF practices increases by 2.2 standard scores in the nutritional status compared to the linear estimate (Equation 1), controlling for other correlates. To test the endogeneity of IYCF practices we performed a first regression in which IYCF practices is explained by all the explanatory variables, including the instruments, and then we predicted the residuals. Next, we ran a second regression in which the dependent variable is the HAZ scores and we tested the individual significance of the residuals. The results (not presented) show that the residuals are significant at the 5% level of significance. With these results, we can conclude that IYCF practices is an endogenous determinant of the HAZ scores. Therefore, the results of 2SLS estimates could be preferable to those from the linear regression which are biased downwards.

- **The effect of IYCF practices on the probability of stunting among children of 6-23 months**

The probit estimate (Equation 3 of Table 5) shows that a unit increase in IYCF practices index reduces the risk of a child being stunted by -6%, controlling for other covariates. This suggests that child nutrition is strongly positively associated with IYCF practices. As it can be seen at the bottom of Table 5, the Wald test of exogeneity suggests a chi2=4.34 with p-value=0.037. This means that the exogeneity hypothesis is rejected; in other words, the correlation between IYCF practices and the error term of the structural equation is different from zero. Therefore, we have to correct for the potential endogeneity bias. Taking into account the potential endogeneity by estimating with the IVProbit (Equation 4 of Table 5), the marginal effect of IYCF practices index is about -0.265, which is too large relative to the probit estimate of -0.062. Thus, accounting for endogeneity increases the absolute value of the probit estimate by 0.203. It is clear that stunting is related to IYCF practices taking into account other socioeconomic variables.

3.2.2. Control function approach estimates of children's HAZ score and probability of stunting

As indicated above, the instrumental variable estimates are unbiased and consistent only when the expected value of the interaction between feeding practices and its residual is zero or the correlation is linear and there is no sample selection problem. Although, we have shown that there is no presumption of sample selection, nothing reassures that the other conditions are fulfilled in order to confirm the consistency of the IV results. Therefore, Table 6 presents control function estimates of the structural parameters of the HAZ score and the probability of stunting.

Thus, the problems due to the effects of endogeneity, non-linearity of unobservables with infant and young children feeding (IYCF) practices is captured by a comparison of the linear regression (Table 5) with estimates derived using control function approach (Table 6). Using the control function approach without the interaction term, the coefficient of IYCF index increases from 0.256 to 0.675 standard scores (Column 1 Table 6) relative to the linear regression estimate (Column 1 Table 5), but significantly lower than the IV2SLS estimate (Column 2 Table 5). Taking into account the possibility of non-linear interactions between IYCF practices and unobservables slightly downgrades the IYCF practices index coefficient to 0.473 standard scores, which is still almost twice the estimate of linear regression. Since the interaction term is statistically highly significant, the IV2SLS estimate of the coefficient of IYCF practices is biased upwards.

Regarding the stunting model, we note that the control function approach under the linear hypothesis, linear interaction of IYCF practices with it residual (column 3 Table 6) improves the IVProbit estimates from -0.265 to -0.619. But when we take into account the non-linear interaction between IYCF practices and unobservable factors that influence children nutrition outcomes (column 4 Table 6), the marginal effect decreases to -0.501, which is still very high than the IVProbit estimate. As suggested in Table 6, the absolute value of the coefficient of the fitted residuals of IYCF practices index is statistically significant at 1% in the HAZ score model but not significant in the stunting model. As the interaction terms between IYCF practices and its residuals are highly statistically significant in the both models, the indication is that IYCF practices are endogenous to child nutrition outcomes, and there is evidence of heterogeneity of response of child nutrition outcomes to IYCF practices. The control function approach has an advantage over the other estimation methods (linear regression, IV2SLS and IVProbit) because it purges the structural parameters of most potential econometric problems, namely endogeneity and heterogeneity of unobservables in presence of an endogenous variable. However, one can note that all empirical specifications generate a positive and highly significant effect of IYCF practices on the HAZ score and the probability of stunting.

Since then, our findings support Ruel and Menon (2002), who investigated the association between child feeding practices and child HAZ scores using DHS data for five Latin America countries. These authors created a composite feeding index to measure feeding practices. They have showed that feeding practices are strongly and significantly associated with the child HAZ scores. Moreover, in the case of BurkinaFaso, Sawadogo et al. (2006), using cross sectional data, find a positive association between the infant and child feeding index and the HAZ scores of children aged 12-23 months but a negative association for the children aged 6-11 months.

In addition, our findings concerning the effect of IYCF practices on the probability of stunting are similar to those of some other studies in the literature (Kismul et al. 2018; Campbell et al. 2018; Fosu-Brefo and Arthur, 2015; Cuanalo De La Cerda, 2007). These studies indicate that good practices of IYCF prevent against stunting early in childhood. For example, using data from the 2014 DRC's DHS, Kismul et al. (2018) have found that early initiation of breastfeeding has lower odds of stunting. Fosu-Brefo and Arthur (2015) have found that timely initiation of breastfeeding, both immediately and hours after birth are important factors that influence the child's health using DHS data from Ghana.

Table 6: Nutritional production function using control function approach

Variables	Model 1 : HAZ score		Model 2 : Stunting (ME)	
	(1)Linear	(1)Non linear	(3)Linear	(4)Non linear
IYCF practices index	0.675***	0.473***	-0.619***	-0.501***
	(0.233)	(0.232)	(0.293)	(0.274)
Household size	-0.002	-0.002	0.037***	0.036***
	(0.001)	(0.001)	(0.008)	(0.007)
Type of place of residence	0.048***	0.048***	-0.179***	-0.174**
	(0.004)	(0.004)	(0.081)	(0.078)
Household asset index	0.414***	0.414 ***	-0.272*	-0.114*
	(0.026)	(0.026)	(0.924)	(0.813)
Household asset index squared	-0.515***	-0.587**	0.324 ***	0.127**
	(0.707)	(0.721-	(0.221)	(0.088)
Household access to improved toilets	0.044***	0.043 ***	-0.155**	-0.149**
	(0.003)	(0.003)	(0.077)	(0.072)
Household has access to piped water	-0.046***	-0.046	0.114	0.108
	(0.002)	(0.002)	(0.070)	(0.066)
Household head is male	-0.014***	-0.014 ***	-0.009	-0.009
	(0.002)	(0.002)	(0.016)	(0.015)
Child's age in months	-0.013	-0.013	-0.083***	-0.083***
	(0.003)	(0.003)	(0.002)	(0.001)
Child's age squared/100	-0.031	-0.032	0.186***	0.182***
	(0.004)	(0.004)	(0.059)	(0.056)
Child is male	-0.231	-0.231	0.381	0.358
	(0.002)	(0.002)	(0.287)	(0.272)
Child's birth size small	-0.165***	-0.165 ***	0.266	0.249
	(0.003)	(0.003)	(0.192)	(0.180)
Child birth weight is low	-0.268***	-0.268 ***	0.418	0.393
	(0.004)	(0.004)	(0.308)	(0.292)
Child is of multiple birth	-0.530***	-0.530 ***	0.756	0.705
	(0.007)	(0.007)	(0.654)	(0.619)
Mother's age	-0.007	-0.007 ***	0.075***	0.073***
	(0.002)	(0.002)	(0.020)	(0.019)
Mother's age squared	0.024	0.024 ***	-0.173***	-0.170***
	(0.004)	(0.004)	(0.052)	(0.049)
Mother's years of education	0.032***	0.032 ***	-0.070*	-0.067*
	(0.001)	(0.001)	(0.042)	(0.039)
Delivered in health facility	-0.034	-0.034	0.051	0.047
	(0.002)	(0.002)	(0.039)	(0.037)
IYCF practices index residual	-0.993***	-------	-1.729	-------
	(0.002)	-------	(1.241)	-------
IYCF practices index times its residual	-------	-0.006 **	-------	-0.001***
	-------	(0.003)	-------	(0.034)
Constant	-0.726***	-0.728 ***	4.243***	4.297***
	(0.193)	(0.192)	(0.660)	(0.621)
Number of observations	33360	33360	33288	33288
R-squared	0.9929	0.9929		
Wald chi2[Prob > chi2]	4670[0.0000]	4697[0.0000]	2734[0.0000]	2803[0.0000]

Source: Author's computation using data from the 2007 & 2014 DHS. ***Note:*** ** p<.1; ** p<.05; *** p<.01 and (…) robust standard errors.*

Table 6 also presents results concerning the effects of the child and maternal characteristics on the one hand and the household and community characteristics on the other. Among them, we note that household size has a significant positive effect on the probability of child stunting but it has no significant effect on the HAZ z-score. Children from urban zones are likely to have good nutrition status (HAZ z-score and stunting) compared to rural children. Household assets depict a U-shaped effect on children's height-for-age z-score and the probability of stunting while access to improved toilets and piped water relate positively with the children's nutrition status measures. The inverted U-shaped relationship between household assets and children's nutritional status implies that children nutrition improves at a decreasing rate with assets. This finding is similar to Sahn and Stifel (2003); Kabubo-Mariara et al. (2008); Mwisha-Kasiwa (2018) who found that asset index is a valid predictor of child health and nutrition.

4. Conclusion

This paper has examined the linkage between the Infant and Young Child Feeding (IYCF) practices and children's nutritional status in Democratic Republic of the Congo (DRC) using the 2007 and 2014 Demographic and Health Surveys (DHS) datasets. Since the IYCF is a multidimensional notion, we constructed an IYCF practices index to take into account all the dimensions of child feeding. The variables used in the IYCF practices index are related to breastfeeding, use of bottle, minimum dietary diversity and number of times child ate solid, semi-solid or soft food. A series of survey-based econometric regressions were used. In estimation, we controlled for endogeneity and heterogeneity arising from unobserved household and maternal characteristics correlated with children's nutritional status and IYCF practices.

The results have showed that infant and young child feeding practices are an important and significant determinant of children's nutritional status as measured by the Height-for-age z-score and the probability of stunting. Specifically, an increase in the IYCF practices index by 1 unit increases by 0.47 standard score in the height-for-age z-score while it reduces the probability of child stunting by -0.5 controlling for other covariates. We also noted that children from urban zones are likely to have good nutrition status (HAZ z-score and stunting) compared to rural children. Household assets have been found to be strongly correlated with children's nutritional status. In addition, among the socio-demographic variables, we observed that younger children are more likely than older children to be stunted, and that the birth weight and the birth size are significant determinants of nutrition status of children aged 6-23 months in DRC. The main recommendation of this paper is that, the DRC's public health ministry should educate parents, especially mothers of children, on the importance of infant and young child feeding practices for the nutrition of their children.

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