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Household size, birth order and child health in Botswana

by

David Mmopelwa

Abstract

One of the theoretical predictions relating to the family size and birth order effect on child capital is resource dilution hypothesis, according to which large sizes and high child birth order are likely to have negative effects. However, there are arguments that the assumption of a fixed and narrow flow of resources from parents underpinning the theory may not always hold. In Botswana, children aged 6-60 months are eligible for monthly food ration provided through the health care facilities. Notwithstanding this, child health as measured by the three anthropometric indicators: stunting (low height for age), being underweight (low weight for age), and wasting (low weight for height) deteriorated overtime, while on average household size declined. This paper investigates the child birth order and alternative family structure (i.e household) size effect on health. Using the 2009/10 Botswana Core Welfare Indicator Survey (BCWIS) data we estimate the random effects model to explore the within and between household effect. We find that children of high birth order are likely to fare worse than their lower birth order counterparts in nutrition. Household size is negatively associated with child health, and there are higher variances across than within households. Higher variances are unexplained by the observed characteristics. The paper calls for further work on the issue of intrahousehold allocation, to aid evaluation of the program in line with the country`s national population policy objective of quality life.

JEL Classification: I12, J12, J13

Keywords: Child health, household size, birth order

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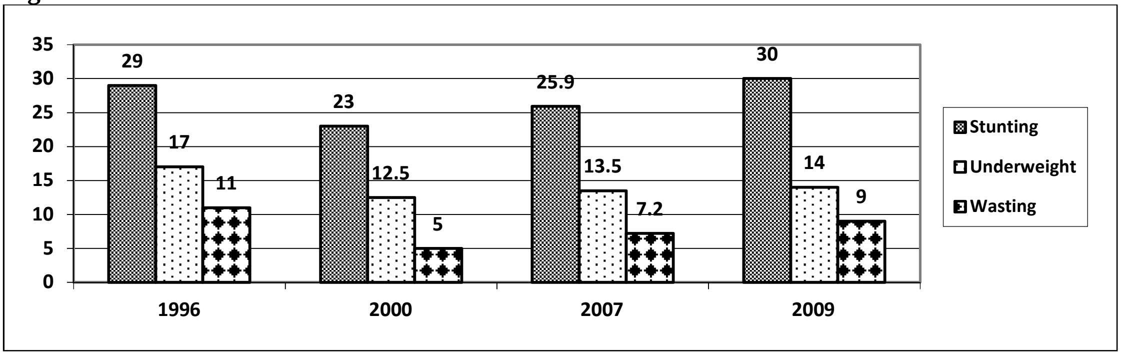
1. Introduction

The effect of early life`s health on both subsequent health and life outcomes has been acknowledged in the literature (Black et al., 2007; Victora et al. 2008; Smith, 2009). Despite acknowledgement that there is a need to address health problems at an early stage in Botswana (Gobotswang, 1993; Tharakan and Suchindran, 1999; Mahgoub et al., 2006; Nnyepi, 2007), statistics show a continuing poor child nutrition (stunting[1], wasting and underweight), which is persistent (CSO, 2009; World Bank, 2015). Figure 1 shows that from 2000, rates for stunting (low height for age), being underweight (low weight for age), and wasting (low weight for height) have increased consistently. This is despite the fact that all children aged 6-60 months are eligible for a monthly food ration at health care facilities through the government`s vulnerable group feeding programme (RVHP, 2011)[2].

Figure 1: Trends in Malnutrition Rates: 1996-2009



Source: CSO (2009); World Bank (2015)

Not only have malnutrition rates increased, but inequality (higher malnutrition rates among children from poor households than from well-off households) has been evident as well (Statistics Botswana and UNICEF, 2008). For instance, in 2007 severe (moderate) stunting rates stood at 19 (17) and 11 (12) per cent for lowest and highest quintiles respectively. Similarly, the proportion of underweight children among the poorest households was 16%, compared to 4% among richer households (Statistics Botswana and UNICEF, 2008). From

1 Of the three indicators, stunting is mostly preferred as it indicates both the past and present nutritional deficiencies (Charmarbagwala et al., 2004)

2 This could reflect the possibility that the ration is redistributed among other household members and therefore reducing gains by the targeted recipients. A thorough evaluation would need to be done to ascertain this, especially that data on underweight produced by the Ministry of Health and Wellness suggests a downward trend, which has been attributed to the ration programme (BIDPA, 2010).

a policy viewpoint, the pattern depicted in Figure 1 is worrying given that there seems to be a reverse of improvements achieved during the 1990s. In this paper we set out to examine factors influencing (deteriorating) child health.

Theoretical predictions regarding the effect of household size and child birth order on child outcomes have been provided through the resource dilution hypothesis, hygiene hypothesis and biologically based arguments (De Keyser and Rossem, 2017; Lundborg et al. 2015; Horton, 1988; Blake, 1981). According to the resource dilution hypothesis large household size and high birth order children imply high costs in terms of caring for children, reducing the parents` likelihood of evenly distributing resources and potentially concentrating resources in those born first (Horton, 1988). Consequently, in a family context, this leads to a trade-off between number of children and their quality measured by their human capital (either education or health); a relationship formally expressed in the quantity-quality model (Becker, 1960, Becker and Lewis, 1974; Becker and Tomes, 1976). This model implies that a negative relationship is to be expected between the number of children and their quality. The hygiene hypothesis postulates that as the number of children increases in the household, the likelihood of health problems, such as infections, increases as well, which negatively affects child nutrition (Lundborg et al. 2015; Horton, 1988). With regards to the biologically based argument, birth order matters because maternal health deteriorates with time: aging mothers are more likely to produce additional children of poorer health (Horton, 1988), although a counter argument is that these children may benefit from their mother`s child care experience.

To investigate the deterioration in child health (Figure 1), we investigate household size and birth order effects on child nutrition. We ask two related questions: could deteriorating child health reflect the effect of household size as theoretically predicted: and how do different birth order children fare in terms of nutrition? The dilution hypothesis assumes resources only come from the parents which has led to a debate in the literature (Desai, 1995; Blake, 1981). In the case of Botswana this may not apply as many children are in the care of extended families so may not rely solely on parental resources.

Although much research on child human capital in both developed and developing countries has focused on education as a measure of quality, evidence on the resource dilution hypothesis is inconclusive (Dasgupta and Solomon, 2018; Zhong, 2017; Lawson and Mace, 2008; Lu and Treiman, 2008; Price, 2008; Desai, 1995 Horton, 1988; 1986).

Some (De Haan, 2010; Black, et al. 2005) find that consideration of birth order attenuates the negative effect of family size on child human capital, although Mogstad and Wiswall (2016) argue that this is because of linearity assumption imposed on family size.

While this inconclusiveness could be due to several factors including the nature of data (i.e cross sectional versus longitudinal), the most cited explanation is that the assumption of a fixed and narrow flow of resources from parents underpinning the theory such as the quantity-quality model, does not hold (Desai, 1995; Blake 1981)[3]. Indeed, some note that households go through a development cycle and that buffering, either at household or national level may reduce the predicted negative effect of family size (Bras et al. 2010). For instance, from demographic survey data for Latin America and Caribbean (Bolivia, Brazil, Colombia, Dominic Republic, Guatemala and Trinidad & Tobago), Asia and North Africa (Egypt, Morocco, Sri Lanka and Thailand) and SSA (Burundi, Ghana, Mali, Senegal, Zimbabwe) countries collected during 1986-1990, Desai (1995) finds that the negative effect of family size is lessened by government assistance, although the effect is not evidenced in all the considered countries. Lu and Treiman (2008) find that in China when schooling opportunities were limited and expensive, children (especially girls) from large families obtained less schooling. However, schooling expansion and affordability reduced the negative effect of having many siblings. They note that demographic, socio-economic and political factors external to the household matter in both resource availability and their intra-household allocation. Shavit and Pierce (1991) find that although educational attainment is negatively affected by nuclear family size, this is not evidenced among extended families in Israel. Therefore, not only do we contribute to this existing debate, but highlight issues for policies and programmes to address child malnutrition.

In Botswana households obtain resources including income and food from a variety of sources, including government programmes, which may reduce children`s reliance on their biological parents. Moreover, unmarried fathers (and mothers to a certain extent) are unlikely to reside with their children, implying that children may not always depend solely on resources from their biological parents. The effect of alternative family structures on child nutrition has not been explored explicitly in the literature. Allowing for the effect of resources sourced from outside the “nuclear family” relates to the anthropological

3 Behrman (1997) classifies this approach to fall into a category she refers to as “consensus parental preferences model of intrahousehold allocation.”

literature, on the relevant definition (or concept) of the African household in assessing child welfare (see Randall and Coast, 2015 and studies cited therein). This literature argues that a definition of a household as recommended by the United Nations (2008) misses both the social and economic interaction of members residing elsewhere (Bongaarts, 2001). Furthermore, while previous work in Botswana has considered household factors, such as house type and household head`s gender, they have not controlled for (or explored) the possible unobserved heterogeneity within households that might explain inequality in child nutrition. We address this gap.

Our work relates specifically to Botswana`s national population policy, which has a goal of “improved quality of life and standard of living” (MFDP and UNFPA, 2010:2). The policy recognises the need to reduce child malnutrition, which has to be informed by an understanding of influential factors that affect malnutrition. Statistics from various censuses show that population growth rate declined from 4.7 in 1981 to 3.5, 2.4 and 1.9 per cent in 1991, 2001 and 2011 respectively. Moreover, the average household size declined from 4.8 in 1991 to 4.15 in 2001 and further to 3.5 in 2011 (Statistics Botswana, 2014). The expectation would be that these declines together with those in fertility rates would be coupled with improved child nutritional status, especially in the presence of the government`s food ration programme and the publicly provided health care. The chapter proceeds as follows: Section 2 reviews related literature; 3 presents data and summary statistics; empirical strategy is presented in 4; results in 5 and section 6 concludes.

2. Related Literature

On the basis of the theoretical predictions highlighted above, there have been efforts to empirically investigate such relationships, both in the developed and developing world. However, it is important to recognize the approach in defining a family and a household, especially that some (Black et al, 2005; De Haan, 2010) have noted the relation between child birth order and family size, as high birth order children within a given family will be from larger sized families. In the Botswana context, where many households comprise children from different families (different mothers), the link between birth order and household/family size is weakened. This is also important as it has a bearing on the framework within which an investigation is carried out, such as sources of resource flows as well as the number of people being considered as diluting resources.

According to Burch (1979:174), “family refers quite generally to a group of kin. i.e person related by blood, marriage or adoption”. On the other hand, “a household is usually defined as a group of persons who make provision for food, shelter and other essentials for living” Bongaarts (2001:263-4). In the context of the latter, which is usually used in national surveys and population censuses, United Nations (2008) states that a household may constitute more than one family, may be made of only one person (whereas family must have at least two), and that in a multi-person household, members do not necessarily have to be related. Therefore, a family is seen as a part of the household and this has implications on both availability and distribution of resources for the production of child health. While these two terms have been used interchangeably in the literature, we consider a household as defined above by Bongaarts (2001). In the following section, we provide empirical evidence regarding the effect of household (and family) size and birth order on child health.

Household Size and Child Health in Developed Countries

Dasgupta and Solomon (2018) find that family size has no effect on child Body Mass Index in the US, although Price (2008) earlier established (for US) that the amount of time spent with children decreases with increasing child birth order, predicting the negative effect of family size on child outcomes. Lundborg et al. (2015) find a positive effect of family size on male individual health in families with first born males and 2 or more births and in those with first and second born males and 3 or more births in Sweden. Lawson and Mace (2008) find a negative effect of family size on child height in Britain. What is commonly acknowledged in this literature is that family size is treated as an endogenous variable resulting in the use of instrumental variable strategy and other approaches such as multi-level models; an approach argued to be able to account for heterogeneity by considering both the context (the environment) and compositional effects in health research (Duncan et al. 1998).

Household Size and Child Health in Developing Countries

Horton (1986) uses cross-sectional data from the Bicol region in the Philippines, to jointly estimate the determinants of fertility (children ever born) and child nutrition (z-score for height for age). She finds that the number of older siblings (brothers and sisters) reduces the child`s nutrition. However, given that the number of younger siblings had a mixed effect, it appears this captured the issue of child`s birth order rather than family size. Indeed, the author makes reference to the effects of birth order in explaining this. Using data from China Nutrition and Health survey to separately estimate urban and rural sample regressions, and one child policy as a source of family size exogenous variation, Zhong (2017) finds that family size has a negative effect on child health for age but not on education. The author specifically tests for the resource dilution hypothesis by dividing the rural sample into three (low, medium and high) income per capita groups and still finds a negative effect of family size on child health.

Mussa (2015) uses the 2006 multiple indicator cluster survey data to investigate intra and inter-household child nutrition inequality in Malawi. Having estimated rural, urban and national regressions, he finds evidence of intra-household gender differences against boys and a positive association between a child`s nutrition and the number of younger siblings, suggesting that the argument for resources may not hold in this case. Kabagenyi and Rutaremwa (2013) find that, although large households had higher infant and child mortality in Uganda, there was no statistical association between them. Through the logistic regression model, they find that children from medium (4-6) sized households are more likely to die than those from small (1-3) sized households. Among other variables, Kabubo-Mariara et al. (2008) consider household size as a determinant of child nutrition in Kenya. Using a pooled sample for the 1998 and 2003 health and demographic surveys, they find a negative association between household size and child height for age.

Ajao et al. (2010) assess the influence of family size and household food security status on child nutrition in Nigeria. Through the binary logistic regression for cross-sectional survey data for mothers of children aged below five, they find that although household food insecurity increases the likelihood of child malnutrition, there is no evidence on the association between family size and malnutrition. On the other hand, Millmet and Wong (2011) find mixed effect in Indonesia. Through the Instrumental Variable approach, they find that moving from a two-child family to the one with more than two has no effect on child`s height for age and body mass index for age. On the other hand, through the estimation of quantile treatment effects, they find that accounting for endogeneity of family size decision results in significant differences only in the distribution of height for age, hence their conclusion that this quantity-quality trade-off is for some quantiles of the distribution.

Birth Order and Child Health in Developed Countries

Lundberg and Svaleryd (2016) investigate the effect of birth order on child health in Sweden using registry data and measuring child health through several indicators. For children aged 0-6 years, they find that compared to first-borns, only the second-borns are less likely to be hospitalised. Moreover, in terms of diagnoses, children of birth order 2, 3 and 4 are less likely to have perinatal and congenital malfunctions. They also find that there is more likelihood for mortality among first born children, a pattern which they say was earlier observed. However, other health indicators (respiratory & eye/ear problems, injuries) are less likely to be evidenced among first born children compared to the second, third and fourth born. They also provide the mechanism through which the effect of birth order on child health manifests. Among them is that mothers` endogenous fertility decision varies with mortality of the first child. They demonstrate that controlling for this reduces the magnitude of the birth order effects.

Brenoe and Molitor (2018) examine this issue in Denmark, with standardised birth weight (adjusted for gestation period) and Apgar score as child health measures. Through the family fixed effect estimation, they find that second, third and fourth born children have better health at birth compared to first borns. Furthermore, these high birth orders reduce the likelihood of both prematurity and the incidence of low birth weight children. The authors demonstrate that the positive effect of birth order on child health was not due to a change in maternal behaviour. They observe a reduction in women working and likelihood of being a student as well as decreasing prenatal care use with increasing birth order. By implication, it could not be argued that mothers cared less for their first birth order children.

Birth Order and Child Health in Developing Countries

A different pattern on the effect of birth order effect on child health emerges in the developing world. Outcomes from empirical investigation generally reveals a negative effect of birth order on child health (Jayachandran and Pande, 2017; Howell et al., 2016; Rahman, 2016; Kebede, 2005; Horton, 1988). From a comparison of Indian and Sub Saharan African children, Jayachandran and Pande (2017) find that although Indians had higher height at birth, the difference decreases for children above second birth order.

According to them this reflects parent intra-household allocation decisions including eldest son preference. Thus, if the first born is a son, there is higher likelihood to not invest in subsequent children, or that if not, earlier born are disadvantaged by the hope of a son. In fact, Jayachandran and Kuziemko (2011) find that this child gender preference result in girls being breastfed for shorter duration than boys. In addition to confirming this, Barcellos et al. (2014) further find that in rural Indian households, child care time for an infant boy was relatively more than that for an infant girl. Rubalcava and Contreras (2000) also find evidence of child preference where mothers channel resources towards their daughters and fathers do to their sons in Chile. For some Africa countries, Sahn and Stifel (2002) find that mothers prefer their daughters while fathers prefer their sons. They arrive at this conclusion after investigating the effect of mothers` and fathers` education on nutritional status for girls and boys respectively.

In Bangladesh, Rahman (2016) finds that the likelihood of being stunted increases with high birth order. Horton (1988) considers the effect of birth order on nutritional status for children aged 15 years and below in the Philippines, through a family fixed effect estimation, which also allowed for interaction of birth order with some other variables, and finds that birth order negatively affects child`s height for age but not weight for height. This implies that children born later are more likely to be stunted than those born earlier, interpreted as suggestive of the effect of resource allocation over time. In particular, the non-significance of birth order on weight for height implies parents` ability to equitably allocate resources, and their inability to do so in the long run as evidenced in the significant birth order effect on child height for age.

Howell et al. (2016) consider 18 African countries (Botswana excluded) and find that high birth order children are more likely to be malnourished. Kebede (2005) considers the effect of birth order on child`s (aged 10 years and below) height for age from a four round (panel) of surveys conducted in 1994, 1995 and 1997 in Ethiopia. Compared to children of 6^{th} or more birth order (reference category), children in the first three birth positions yield significantly higher height for age. No significant differences are evidenced for those in the fourth and fifth positions. The author also finds that height for age declines with increasing birth position. He attributes this to biological factors and parental behaviour (i.e possibilities of elder child preference), with an alternative explanation of resource dilution.

Using demographic and health survey data from 14 African countries, Sahn and Stifel (2002) find that among children aged 3-36 months, birth order positively associates with child height for age and negatively with child weight for height. Compared to first born children, second and third borns have higher height for age while fifth and higher birth order have no effect. On the other hand, they also find that later born children are more likely to be wasted. In Kenya Kabubo-Mariara et al. (2008) find that birth order has no significant effect on child height for age, although it carried a negative sign. However, they find an increased likelihood (through binary regression) for stunting with increasing birth order. Yassin (2000) finds that although high birth order increased the likelihood for child mortality in bi variate analysis, no effect is evidenced through the multivariate analysis in rural Egypt.

It emerges from the existing literature that there are differences in child birth order effects on health. The pattern generally observed in developing countries is the opposite of evidence in the developed world: high birth order children are likely to fare worse in developing than in developed countries. A similar pattern is observed by De Haan et al. (2014), for studies that consider education. Even on the mechanism that could explain the birth order effect, one study in the US (Price, 2008) find that the incidence of mother's quality time accorded to the child decreases with increasing birth order. On the contrary, the opposite is evidenced in Ecuador (De Haan et al. 2014) and that boys in India have more care time than girls (Barcellos et al. 2014). Moreover, while generally birth order has negative effect, there are indications of some positive effect as well, suggesting that the effects may not be conclusive. Hence our study contributes to this debate.

3. Data and Summary Statistics

We use the 2009/10 Botswana Core Welfare Indicator Survey (BCWIS) data, collected by Statistics Botswana during the period from April 2009 to March 2010. This national survey is an improvement of the previous Household Income and Expenditure Surveys as it covers other non-income welfare indicators such as child nutrition which we consider in this paper. The survey used a two-stage stratified probability sampling, with the first and second stages being selection of primary sampling units (Enumeration areas) and occupied households respectively. A total of 7,732 households with 27,308 individuals were covered in the three strata; cities/towns, urban villages and rural areas. The survey sourced information on socio economic and demographic characteristics of households and their members. For all births that mothers had, they were asked to provide child age, sex and birth order information. The key piece of information that we use in this chapter is knowledge about the biological parents, namely if they were still alive at the date of interview, lived in the same household with their children and if not, whether children received support from them.

From the individual data file, we extracted data for children aged 5 years and below[4], and merged it with the household data file, resulting in a sample of 3,873 children. To measure child nutrition, we computed the standardized child nutritional indicators through the World Health Organisation (WHO) software for growth and development of the world`s child (WHO, 2011). This software requires information on child age (in months), sex, height and weight. It then transforms height for age, weight for age and weight for height into z scores, as standardized measures of their deviation from the median of the reference population. Specifically, the approach takes the difference between individual child`s observation and median reference value and divides it by the standard deviation of the reference population (i.e children of the same age). The composition of the reference population changed over time, from the US National Center for Health Statistics (NCHS) data to the current reference population, which is an outcome of a WHO Multi Growth Reference study (MGRS) of six countries: Brazil, India, Norway, Oman and the USA (WHO, 2011). The interpretation is such that a z-score in the range between -2 and +2 standard deviation from the median of the reference population implies a normal growth, otherwise the child is considered malnourished. Z scores for weight for height higher than 2 standard deviations from the reference median indicate an increased likelihood of being overweight.

4 The sample is restricted to children aged five years and below as this is the only group of children for whom anthropometric indicators are monitored (through surveys) over time. Additionally, government through the Ministry of Health and Wellness, monitors child underweight until the child is aged 5 years.

Table 1: Definitions of variables

Variable	Definition	BFHS	BCWIS
Outcome variables			
WAZ	Standardized z scores for weight for age	√	√
HAZ	Standardized z scores for height for age	√	√
WHZ	Standardized z scores for weight for height	√	√
Child Characteristics			
BO1	An indicator for a first birth order child		√
BO2	An indicator for a second order child		√
BO3	An indicator for a third birth order child		√
BO4+	An indicator for a fourth or higher birth order child		√
MaleC	An indicator of a male child, 1=Yes, 0 otherwise	√	√
Breastfed	Child ever breastfed (1=Yes)	√	
AGEC	Child age in months	√	√
Diarrhoea	Child had diarrhoea two weeks before the survey, 1=Yes	√	√
MOTLIVEH	Child`s mother lives with the child in the same household, 1=Yes	√	√
FATLIVEH	Child`s father lives with the child in the same household, 1= Yes	√	√
FatContribute	Whether child`s father contributes to his/her support on regular basis, 1=Yes		√
Grand Child	Child is a grandchild to the household head	√	√
Son/Daughter	Child is a son/daughter to the household head	√	√
Other relative	Child has other relation to the household head	√	√
Mother`s Characteristics			
Mother`s age	Mother/carer`s age (years)	√	√
Mother Married	Mother is married	√	√
Pre-Primary	Mother has pre-primary education	√	√
Junior Secondary education	Mother has junior secondary education	√	√
Post-JSecondary education	Mother has post-junior secondary education	√	√
Household Characteristics			
MaleHH	An indicator of a male household head, 1=Yes		√
AgeHH	Age of the household head in completed years		√
MarriedHH	Whether the household head is married, 1=Yes		√
EDUHH	Education of the household`s head (Years of schooling)		√
HHSZ	Number of household members	√	√
Children<1 year	Number of children aged less than 1 year		√
Children 1-3 years	Number of children aged 1-3 years		√
Children 4-5 years	Number of children aged 4-5 years		√
Piped Water	Household has piped water in yard (indoors or out) (1=Yes)		
Communal tap	Household water sourced from communal tap (1=Yes)	√	√
Other	Household water sourced from other (1=Yes)	√	√
Own Flush toilet	Household owns a flush toilet (1 =Yes)	√	√
Own Pit latrine	Household owns a pit latrine (1 =Yes)	√	√
Communal flush toilet	Household uses communal flush toilet (1 =Yes)	√	√
Communal pit	Household uses communal pit latrine (1 =Yes)	√	√
Communal VIP	Household uses communal VIP (1 =Yes)	√	√
Neighbour's toilet	Household uses neighbour`s toilet (1 =Yes)	√	√
Rural	Rural area residence	√	√

However, for each nutritional indicator the total sample size varies according to availability. There are cases where a child`s weight is available while height is not, and reasons for the missing information are not provided in the data. Furthermore, some children have standardized z scores outside the WHO`s recommended range. According to WHO (2011), a range for weight for age, height for age and weight for height is between -6 & 5, -6 & 6 and -5 & 5 respectively, hence any score outside these ranges should be excluded from the analysis. Overall, we are able to analyse a sample range of 2863-3481 children depending on the outcome measure.

For robustness checks, we also consider the 2007/08 Botswana Family Health Survey (BFHS) data, also collected by Statistics Botswana. This covers 2532 children aged 5 years and below. The variables informed by literature review (although limited by data) are defined in Table 1 below. It is important to note the variation in the variable availability between these two data sets. BCWIS for instance did not collect information on child breastfeeding while BFHS does not have a birth order variable. We provide definitions for all variables found in both surveys and which variables are available.

2.2.2 Summary Statistics

Prior to presenting the summary statistics, we show the within household structure by gender of the household head (Figure 2). There are higher frequencies for head`s son/daughter within male headed households than in female headed households. However, the opposite is evident for grandchildren and other relationships. Moreover, although there is higher likelihood for fathers (mothers) to reside with their children in male (female) headed households respectively, the pattern provides a basis for parents-child resource flow. Thus, not all parents are heads of households and the lower shares for mother-child resident in male headed households and father-child resident in female headed households suggest that resources cannot be assumed to be solely from biological parents.

Another factor relating to household structure is on the child age-birth order link. In a typical (nuclear) family, it is expected that high birth order children should be younger. However, in the case of household (in the African context), there are possibilities of children of the same age with different birth order, or children of the same birth order with different child age. We show these, but only for households with at least two children (n=2292). In such households, a total of about 37% of children have same birth order, but different ages, while 2% have same age but different birth order. There are also cases where a lower birth order child in a specific household is younger than a different high birth order child. All these are due to the household nature; different mothers in the household which as argued, affect both the source and distribution of resources for child care.

Summary statistics are shown in Table 2. The average height for age Z score of -0.928 implies that the children in this sample are about 0.9 standard deviations below the median of the reference population. First birth position (BO1) accounts for almost half of the children (41%), followed by second and fourth or higher birth order with shares of 27 and 18 per cent respectively. An examination of nutritional indicators by birth order reveals that generally, nutrition worsens with increasing birth order (Table 3). Approximately 49 per cent of children are males and 10 per cent report having had an incidence of diarrhoea two weeks preceding the survey. Although biological parents are alive for more than 95 per cent of children, mothers are more likely than fathers to be staying with them in the household. The pattern might partly be explained by the low rates of married individuals in the country, which has been attributed to delayed time to marry due to cohabitation (Mokomane, 2005). Traditionally, in cases of unmarried parents, there is higher likelihood of children staying with their mothers than their fathers. About 67 per cent of children not living with their fathers do receive regular contributions from their fathers.

Considering the relationship of the children to the household head, the majority, 49 per cent, are grandchildren and 39 per cent are sons/daughters. Other relation (nephews/nieces, step children) account for 12 per cent. An average of 44 per cent of children are from male headed households while average household head`s age is 49 years. Table 2 also shows that around 34 per cent of children are from households whose heads are married. They are followed by those from households whose heads are living together (24%), never married (23%) and widowed (15%) respectively. The lowest share (1%) is accounted for by those whose heads are separated, while the divorced average about 2 per cent.

On average, household heads have about 5 years of schooling. For the biological parents, demographic information is only available for those who were residing with their children. Only 37 per cent of children resided with their biological fathers, implying that fathers' information is not available for majority of children (non-residing fathers did not provide information). For the sample of children residing with their mothers we find that about 40 per cent are for mothers with junior secondary education followed by those with post junior secondary and primary education (Table 4). Regarding the marital status, a larger share (46%) are never married, 32% living together[5], 20% married and 10% each for separated and widowed. Furthermore, no information on parents` ethnicity were sourced during the survey. The average size of the household is 6 (Table 2). A further investigation into the household structure is through the categorization of the number of children by age. As shown, the majority of children are from households with children aged 1-3 years. About 51% of children are residing in rural areas; 34% and 16% were in urban areas and cities/towns respectively. Table B1 in the appendices presents summary statistics from BFHS and shows that on average the two survey data have a similar pattern.

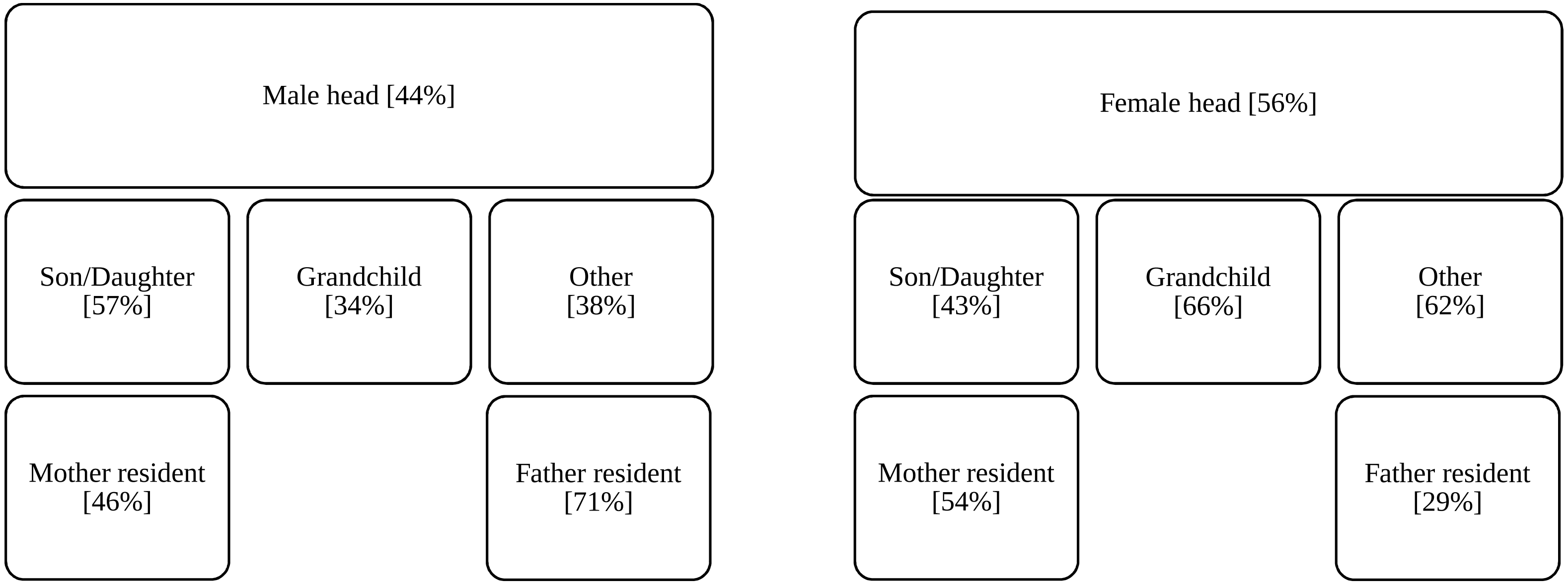
Table 2: Summary Statistics

Variable	Mean	Standard Dev
Dependent		
WAZ	-0.179	2.866
HAZ	-0.928	2.003
WHZ	0.772	4.859
Independent		
Child Characteristics		
BO1	0.408	0.492
BO2	0.274	0.446
BO3	0.135	0.342
BO4+	0.178	0.382
MaleC	0.491	0.500
AGEC	32.850	18.833
Diarrhoea	0.096	0.295
MotliveH	0.784	0.412
FatliveH	0.374	0.484
Fat contributes	0.665	0.472
Grand Child	0.486	0.500
Son/Daughter	0.388	0.487
Other relative	0.116	0.320
Household Characteristics		
MaleHH	0.438	0.496
AgeHH	49.183	16.321
MarriedHH	0.342	0.474
EDUHH	5.151	5.174
HHSZ	6.975	3.473
Children <1 year	0.335	0.541
Children 1-3 years	1.045	0.883
Children 4-5 years	0.850	0.841
Rural	0.506	0.500

Source: author`s computation from BCWIS data.

5 We do not observe whether the male partners are biological fathers to the children

Figure 2: Household Tree diagram



Source: author`s computation from BCWIS data

Table 3: Nutritional Indicators Summary Statistics by Birth order

Birth Order	WAZ	Underweight	HAZ	Stunted	WHZ	Wasted
1	-0.336	0.123	-0.865	0.268	0.106	0.108
2	-0.391	0.143	-1.008	0.295	0.130	0.109
3	-0.437	0.176	-0.842	0.251	-0.090	0.152
4+	-0.601	0.159	-1.161	0.336	-0.024	0.122

Source: author`s computation from BCWIS data

Table 4: Summary Statistics for Child with Mothers in Household

Variable	Mean	Std. Dev.
BO1	0.347	0.476
BO2	0.270	0.444
BO3	0.164	0.370
BO4+	0.213	0.410
MaleHH	0.458	0.498
AgeMother	29.695	7.236
Pre-Primary	0.279	0.448
Junior Secondary	0.395	0.489
Post Junior Secondary	0.309	0.462
Mother Married	0.199	0.399
Mother Living together	0.321	0.467
Mother Separated	0.010	0.099
Mother Divorced	0.004	0.067
Mother Widow	0.010	0.098
Mother Never married	0.455	0.498
Son/Daughter	0.498	0.500
Grand Child	0.387	0.487
Other Relation	0.107	0.309

Source: author`s computation from BCWIS data

4. Model Specification

4.1 Theoretical Model

Studies on production of human capital (either health or education) at the household level are usually based on the Becker (1965) model, which incorporates non-market dimensions into household production (Strauss and Thomas, 1995). Time and goods are allocated for the production of commodities, some of which are sold in the market, while some are consumed at home, partly because no market exists for them. In this framework it is assumed that households have a utility function that represents their preferences and determined by the consumption of commodities X and leisure L, formalised in equation 1 below:

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

The household optimally chooses consumption bundle subject to both budget and time constraints. According to the budget constraint total market consumption cannot be more than the total income, which includes both non-labour and labour earnings. On the other hand, total time includes leisure, time for home production and time for work in the market. Although the initial assumption on perfect substitutability between market and home-produced goods was maintained in the model for a single person household (Gronau, 1977), Strauss and Thomas (1995) state that this assumption can be relaxed on the basis that most of the human capital cannot be purchased in the market. In the context of child health, such modification considers the possible integration of biological, demographic and socio-economic factors. Therefore equation 1 gets modified to include child health, which in our case is measured by the anthropometric indicators for those aged 5 years and below. In this case it is assumed that the production of child health is done on its own right and directly enters the household utility function.

4.2 Empirical Model

Following the approach in the literature (Strauss and Thomas, 1995), our basic model is specified as follows:

$$n_{ch} = \beta_0 + \beta_1 X_{ch} + \beta_2 \theta_{ch} + \varepsilon_{ch} \qquad (2)$$

In (2) n_{ch} is child nutrition as measured by the standardized z scores of weight for age, height for age and weight for height for child *c* residing in household *h*; X_{ch} represents specific child characteristics while θ_{ch} is a vector for household characteristics. We also estimate binary regressions for which the dependent variable is equal to 1 if child is malnourished (z score< -2) and 0 otherwise. Equation 2 is also estimated by including village and district fixed effects with clustered standard errors to control for any unobserved heterogeneity at both village and district levels. The literature suggests issues to address in the empirical investigation. One is that family completeness may introduce bias on the effect of birth order (Horton, 1988): a certain birth order for a family whose size is yet to increase may be inappropriately considered as the last, while in fact that could be a middle one. Horton (1988) notes that the inclusion of mothers' age could partly address this issue, though imperfectly. We do not necessarily compare the first with last, but rather investigate the effect of different birth orders on child nutrition. Thus, we do not assume that the number of children is complete.

Another issue is that of endogeneity of household size. Previous work that considered family size used the instrumental variable approach (De Haan, 2010; Black, et al. 2005, Dasgupta and Solomon, 2018) while others used household fixed effect model (Horton, 1988). There seems to be a consensus that household size is influenced by several factors such as fertility, mortality and migration (Hoddinott and Mekasha, 2017; Bongaarts, 2001), which are also determined by other factors. For instance, fertility is determined by the female`s ability to give birth (fecundity), incidence of marriage, as well female labour force participation; a contributing factor for the declining TFR in Botswana (Mills, et al. 2010). Although marriage, in the context of nuclear households, has been viewed as an exposure to child birth (Bongaarts, 1982), in Botswana there are incidences of pre-marital births. Data shows that during the period 2001-2011 the number of registered marriages was almost constant at about 4000 per year (Statistics Botswana, 2014a). Moreover, marriage decision can be a source of migration in or out of the household. Two studies in Africa (Hoddinott and Mekasha, 2017 in Ethiopia and Hamoudi and Thomas, 2014 in South Africa) find that household size changes in response to public social protection programmes. Hoddinott and Mekasha (2017) demonstrate that the increase in household size was not due to increased fertility since participation in the Productive Safety Net Programme reduced the likelihood (among adult female members) of fertility. According to them household size increased because of the increase in the number of females aged 12-18 years, whose outmigration was reduced by their delayed marriage, possibly because they had to take over tasks previously performed by their mothers.

Changes in household size are tracked through population censuses and some national surveys. However, these may not adequately capture the dynamics of household size change since they do not follow same households over time. Table 5 presents some demographic indicators for Botswana to shed light on household size patterns over time. The table shows that after an increase during 1971-1981, both crude death and birth rates consistently declined over time. Total fertility rates also declined, despite the increase in the share of women (out of total women) of reproductive age (15-49). The 2006 Botswana Demographic survey shows that age specific fertility rates are higher among females aged

20-24 years, a pattern observed in both rural and urban areas (CSO, 2009). The table shows that the number of households increased over time and the average household size declined. This seems to suggest a pattern where, from the increased population size, they were new households.

The proportion of those in urban areas increased, implying possibilities of migration. Indeed, data from the 2006 Botswana Demography Survey shows that 45% of migration was from rural to urban areas (CSO, 2009a). Urban to rural area migration stood at 21 per cent, while urban to urban and rural to rural recorded 23 and 10 per cent respectively. Moreover, 36 per cent of internal citizen in-migrants reported that they migrated to join their parents, followed by those who cited job station/transfer (24%). On the other hand, among the non-citizens high rates were for job related factors. With regards to out-migration, among cities/towns it was dominated by visit/vacation/leave while in rural areas it was mainly for educational purposes. Incidents of twin births (which has been used as an instrument for family size elsewhere) is very low in Botswana. For instance, of the total 39,368 live births registered in 2011 only 397 (about 1 per cent) were twins (Statistics Botswana, 2014a) and twins are not observed in either the 2007/08 BFHS or 2009/10 BCWIS data.

Table 5: Demographic Indicators; 1971-2011

Year	CDR	CBR	TFR	% of Women aged 15-49	% Urban	No. of HH	Average HH size
1971	13.7	45.3	6.5	42.8	9.0		
1981	13.9	47.7	6.6	42.9	17.7	170,833	5.5
1991	11.5	39.3	4.2	46.5	45.7	276,209	4.7
2001	12.4	28.9	3.3	52.4	54.2	404,706	4.2
2006	11.2	29.8	3.2	-	-		
2011	6.25	25.7	2.8	54.4	64.1	550,920	3.7

Source: MFDP (2017)

To control for the unobservables within and across households, we follow Mussa (2015), which is an extension of Picard and Wolff (2010)[6]. The approach involves obtaining both the explained and unexplained variation in child nutritional status across and within households in three steps. In the first step, a linear random effect model is estimated using maximum likelihood and fitted values of child nutritional indicators are obtained together with two random residuals for child and household unobservables. In the second step, the

6 Following work on intrahousehold allocation by Behrman (1997) among others, these authors provide a review of literature on intrahousehold decisions and educational outcomes, and estimate a random effect model, to compute variances for education inequality in Albanian households.

mean child nutritional status for each household is computed. The third step, aided by outcome of the first two steps, involves calculation of variances, which are used to compute contribution of each components. This enables us to identify the contribution of the observed child and household characteristics as well as the proportion accounted for by the unobservables. The model is re-specified as follows:

$$n_{ch} = x'_{ch}\beta + \varepsilon_{ch} \qquad c=1 \ldots C; \quad h=1\ldots H \tag{5}$$

$$\varepsilon_{ch} = u_h + z_{ch} \tag{6}$$

Where n_{ch} and x_{ch} are as previously defined. The key component in this specification is that the random error term ε_{ch} includes two errors; one for the household unobserved heterogeneity (u_h), and the other specific to the child (z_{ch}). These two errors (u_h and z_{ch}) are assumed to be independent and normally distributed. However, it is assumed that only the variance for the within unexplained part, z_{ch} is normalised to 1 (i.e., z_{ch} ~N (0; 1) and u_h~N (0, δ^2_u). From equation (5) the equation for fitted values is obtained (equation 7), which can further be rewritten in mean deviation form (equation 8) using an overall mean ($\bar{n}$) and estimated mean ($\bar{\hat{n}}$) of nutritional indicators.

$$n_{ch} = \hat{n}_{ch} + \hat{\varepsilon}_{ch} \tag{7}$$

$$(n_{ch} - \bar{n}) = (\hat{n}_{ch} - \bar{\hat{n}}) + \hat{\varepsilon}_{ch} \tag{8}$$

Rearranging after some adjustments, total variation is made of explained and unexplained variations (terms in the first and second brackets respectively). Furthermore, both variations are composed of between and within explained and unexplained variations. For instance, the between and within unexplained variations are represented by the last two terms (in the last squared bracket) of the entire equation.

$$\sum_{h=1}^{H}\sum_{c=1}^{C}(n_{ch} - \bar{n})^2 = \left[\sum_{h=1}^{H} C\left(\bar{\hat{n}}_h - \bar{\hat{n}}\right)^2 + \sum_{h=1}^{H}\sum_{c=1}^{C}\left(\hat{n}_{ch} - \bar{\hat{n}}_h\right)^2\right] + C\left[\sum_{h=1}^{H}\hat{u}^2{}_h + \sum_{h=1}^{H}\sum_{c=1}^{C}\hat{z}^2{}_{ch}\right]$$

Lastly, the proportions of variances to the total are obtained. For instance, the proportion of explained variation across the households is computed as follows:

$$\frac{\frac{\sum_{h=1}^{H} C\left(\bar{\hat{n}}_h - \bar{\hat{n}}\right)^2}{h-1}}{\frac{\sum_{h=1}^{H}\left(\bar{\hat{n}}_h - \bar{\hat{n}}\right)^2}{h-1} + \frac{\sum_{h=1}^{H}\sum_{c=1}^{C}\left(\hat{n}_{ch} - \bar{\hat{n}}_h\right)^2}{c-1} + \frac{c\sum_{h=1}^{H}\hat{u}^2{}_h}{h-1} + \frac{\sum_{h=1}^{H}\sum_{c=1}^{C}\hat{z}^2{}_{ch}}{c-1}}$$

Where the numerator is explained inequality across households. The denominator is a total of explained inequality across households, explained inequality within households, unexplained inequality in nutrition across households and unexplained inequality within households respectively. The proportions of other variances are computed in a similar manner.

5. Results and Discussions

Table 6 presents OLS and random effect regression results while probit results are presented in Table 7. We discuss them concurrently. OLS result show that compared to first order child (reference category), birth orders of 3 and 4 or more are negatively associated with weight for age. Weight for age of child`s birth order 3 and 4+ is 0.216 and 0.363 standard deviations lower than that of first birth order. These are supported by the probit model results, which show that the likelihood of being underweight increases with increasing birth order. Similarly, birth order 4 and above is negatively associated with child weight for height and increases the likelihood for child stunting. Birth order 3 is negatively associated with weight for height. Overall, these suggest that children of high birth order are likely to fare worse than their lower birth order counterparts in terms of child nutrition.

It is important to note that our approach considers an extended family, hence we do not assume that resources for the child`s growth and development are sourced merely from the child`s biological parents. Therefore, the results may suggest that for Botswana there could be an insight of the psychological birth order, which has been defined as “the role the child adopts in his/her interactions with others” (Eckstein, et al 2010:409). According to this definition, psychologically, the child`s outcome is affected by his/her household situation. However, given that we are considering children aged below 5 years, it is more likely that in an extended family they are likely to be disadvantaged by entering the household late.

Table 6: Regression Results for Child Nutritional Indicators

	OLS			Random Effect		
Independent Variables	**WAZ (1)**	**HAZ (2)**	**WHZ (3)**	**WAZ (4)**	**HAZ (5)**	**WHZ (6)**
BO2	-0.110	-0.001	-0.174	-0.091	-0.006	-0.184
	(0.090)	(0.123)	(0.117)	(0.086)	(0.121)	(0.112)
BO3	-0.216*	-0.020	-0.356**	-0.188	-0.039	-0.390**
	(0.121)	(0.155)	(0.161)	(0.118)	(0.165)	(0.152)
BO4+	-0.363***	-0.356**	-0.135	-0.307***	-0.349**	-0.086
	(0.116)	(0.154)	(0.143)	(0.112)	(0.154)	(0.144)
MaleC	-0.109	-0.112	0.038	-0.093	-0.109	0.019
	(0.085)	(0.117)	(0.109)	(0.081)	(0.113)	(0.105)
MaleC*BO2	0.000	-0.277	0.258	-0.003	-0.282	0.272*
	(0.132)	(0.183)	(0.171)	(0.126)	(0.177)	(0.164)
MaleC*BO3	0.130	0.097	0.098	0.131	0.058	0.161
	(0.172)	(0.226)	(0.222)	(0.160)	(0.225)	(0.208)
MaleC*BO4+	0.150	0.133	-0.122	0.127	0.126	-0.139
	(0.151)	(0.200)	(0.166)	(0.144)	(0.203)	(0.185)
AGEC	-0.011***	-0.009***	-0.019***	-0.010***	-0.009***	-0.019***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
Diarrhoea	-0.120	0.013	-0.149	-0.144	0.004	-0.156
	(0.100)	(0.145)	(0.131)	(0.095)	(0.133)	(0.124)
MOTLIVEH	-0.145**	0.001	-0.025	-0.107	0.013	-0.016
	(0.073)	(0.098)	(0.095)	(0.075)	(0.101)	(0.094)
FATLIVEH	0.061	0.125	0.142	0.069	0.101	0.216
	(0.135)	(0.169)	(0.155)	(0.137)	(0.184)	(0.172)
FatContribute	0.173**	-0.018	0.124	0.165**	-0.012	0.122
	(0.069)	(0.094)	(0.090)	(0.071)	(0.095)	(0.089)
Fatliveh*FatContribute	-0.076	-0.168	-0.090	-0.107	-0.150	-0.197
	(0.158)	(0.208)	(0.190)	(0.163)	(0.218)	(0.205)
Son/Daughter	0.266**	0.354**	0.094	0.239**	0.369**	0.099
	(0.110)	(0.156)	(0.140)	(0.110)	(0.149)	(0.140)
Other Relative	0.184*	0.359	0.067	0.109	0.348**	0.001
	(0.102)	(0.140)	(0.130)	(0.105)	(0.139)	(0.133)
MaleHH	-0.052	-0.074	-0.073	-0.034	-0.077	-0.058
	(0.071)	(0.095)	(0.092)	(0.078)	(0.101)	(0.098)
AgeHH	0.042***	0.043***	0.011	0.040***	0.045**	0.006
	(0.010)	(0.015)	(0.014)	(0.012)	(0.016)	(0.015)
AgeHHSQ	-0.000***	-0.000**	-0.000	-0.000**	-0.000**	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
MarriedHH	0.140**	0.164*	-0.003	0.124	0.161	-0.016
	(0.070)	(0.096)	(0.088)	(0.077)	(0.100)	(0.097)
EDUHH	0.028***	0.030***	0.024***	0.034***	0.031***	0.027***
	(0.007)	(0.009)	(0.009)	(0.008)	(0.010)	(0.010)
HHSIZE	-0.027***	-0.033**	0.002	-0.034***	-0.028*	-0.007
	(0.010)	(0.013)	(0.012)	(0.011)	(0.015)	(0.014)
Rural	-0.202***	-0.038	-0.091	-0.173***	-0.027	-0.077
	(0.058)	(0.077)	(0.073)	(0.064)	(0.082)	(0.080)
Log Likelihood				-6431.467	-6315.098	-5731.163
Chi^2				143.16	84.98	130.90
Prob> Chi^2				0.000	0.000	0.000
Between Explained				0.314[8.20]	0.290[5.11]	0.258[5.31]
Between Unexplained				2.965[77.47]	4.402[77.45]	3.867[79.53]
Within Explained				0.018[0.47]	0.037[0.65]	0.043[0.893]
Within unexplained				0.531[13.87]	0.953[16.76]	0.694[14.26]
Observations	3481	3013	2863	3481	3013	2863

*, **, *** significant at 10, 5 and 1 per cent respectively. Robust Standard Errors are in parenthesis

Table 7: Probit Results for Child Malnutrition

Independent Variables	Underweight (1)	Stunting (2)	Wasting (3)
BO2	0.035*	0.033	0.004
	(0.021)	(0.028)	(0.020)
BO3	0.047*	0.055	0.024
	(0.027)	(0.038)	(0.026)
BO4+	0.063**	0.060*	0.004
	(0.025)	(0.033)	(0.025)
MaleC	0.045**	0.015	0.014
	(0.019)	(0.025)	(0.019)
MaleC*BO2	-0.024	0.093**	0.013
	(0.029)	(0.040)	(0.030)
MaleC*BO3	-0.004	0.013	0.022
	(0.036)	(0.052)	(0.036)
MaleC*BO4+	0.065*	0.042	0.006
	(0.033)	(0.044)	(0.033)
AGEC	0.000	0.004***	0.000
	(0.000)	(0.000)	(0.000)
Diarrhoea	0.027	0.026	0.010
	(0.020)	(0.028)	(0.021)
MOTLIVEH	0.032*	0.031	0.021
	(0.017)	(0.022)	(0.017)
FATLIVEH	0.008	0.004	-0.011
	(0.029)	(0.039)	(0.030)
FatContribute	-0.009	-0.007	-0.007
	(0.015)	(0.020)	(0.015)
Fatliveh*FatContribute	-0.032	-0.010	-0.002
	(0.034)	(0.047)	(0.035)
Son/Daughter	0.024	-0.036	0.027
	(0.024)	(0.032)	(0.024)
Other Relative	0.028	-0.034	0.004
	(0.022)	(0.030)	(0.022)
MaleHH	0.028*	0.005	0.012
	(0.015)	(0.021)	(0.016)
AgeHH	-0.004*	-0.004	0.003
	(0.002)	(0.003)	(0.002)
AgeHHSQ	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
MarriedHH	-0.037**	-0.003	0.000
	(0.015)	(0.021)	(0.015)
EDUHH	-0.003*	-0.008***	-0.002
	(0.002)	(0.002)	(0.002)
HHSIZE	0.005**	0.010***	0.001
	(0.002)	(0.003)	(0.002)
Rural	0.035***	-0.008	0.008
	(0.012)	(0.017)	(0.013)
Log Likelihood	-1391.131	-1720.301	-1021.783
Chi^2	64.20	157.73	18.09
$Prob>Chi^2$	0.000	0.000	0.7006
Observations	3481	3013	2863

*, **, *** significant at 10, 5 and 1 per cent respectively. Robust Standard Errors are in parenthesis.

Male children have increased likelihood of being underweight, but we find no effect of gender on child stunting. Age of the child is negatively associated with all the three nutritional indicators and increases the probability of child malnutrition. Contrary to expectation, OLS results show that the presence of a child`s mother is negatively associated with child weight for age and increases the probability of underweight. Perhaps this may have to do with the characteristics of these mothers as opposed to their presence/absence in the household. Or perhaps a possibility that more disadvantaged mothers are more likely to join an extended family and to have lower health quality children. To assess their effect on child nutrition, we later separately present the results for those children who were residing with their mothers in the household. The incidence of father contributing towards the support of the child is positively associated with weight for age. However, an interaction of the father’s absence with contribution towards the child support does not have any effect on child nutrition. Compared to grandchildren, sons/daughters are positively associated with weight for age and height for age, suggesting a possibility that parents are more likely to prefer their biological children. However, the positive sign accompanying other relations for height for age is not easy to interpret. It could be explained by the characteristics of their biological parents (or other unobserved factors). It could be that those grandchildren in an extended family to be looked after by grandparents tend to be less healthy, possibly because their mothers are younger and/or disadvantaged. Age of the head of household is positively associated with weight for age and height for age; from the probit results, this reduces the probability of child underweight. The household head`s years of schooling is positively associated with all the indicators,. Household size is negatively associated with weight for age and height for age and increases the child`s likelihood of both being underweight and stunted. This may be interpreted to reflect the prediction of resource dilution in the household. Rural area residence is negatively associated with weight for age and increases the likelihood of child underweight.

Decomposed variances and their proportions (in squared brackets) are presented in the bottom of Table 6. Overall, larger shares of variance are from between than within households. For instance, the weight for age between variance accounts for about 85 per cent, while the rest is for the within variance. In Table 6, for all the three indicators, the unexplained components account for larger variance than explained; more than 75 per cent between and more than 13 per cent within households. As for the explained component, there is less within variance than between household variance.

Table 8: Regression results for Child Nutritional Indicators (omitting household size)

	OLS			Random MLE		
Independent Variables	**WAZ (1)**	**HAZ (2)**	**WHZ (3)**	**WAZ (4)**	**HAZ (5)**	**WHZ (6)**
BO2	-0.105	-0.004	-0.170	-0.090	-0.001	-0.184
	(0.091)	(0.123)	(0.118)	(0.087)	(0.122)	(0.113)
BO3	-0.232*	-0.015	-0.346**	-0.205*	-0.012	-0.391**
	(0.120)	(0.152)	(0.160)	(0.118)	(0.164)	(0.152)
BO4+	-0.370***	-0.383**	-0.122	-0.323***	-0.372**	-0.086
	(0.116)	(0.152)	(0.143)	(0.112)	(0.154)	(0.144)
MaleC	-0.113	-0.122	0.037	-0.096	-0.117	0.017
	(0.085)	(0.117)	(0.109)	(0.080)	(0.112)	(0.105)
MaleC*BO2	0.009	-0.247	0.254	0.002	-0.257	0.273*
	(0.132)	(0.183)	(0.172)	(0.126)	(0.176)	(0.164)
MaleC*BO3	0.154	0.127	0.102	0.150	0.082	0.169
	(0.172)	(0.224)	(0.222)	(0.160)	(0.224)	(0.208)
MaleC*BO4+	0.147	0.146	-0.122	0.127	0.136	-0.139
	(0.151)	(0.199)	(0.143)	(0.144)	(0.202)	(0.185)
AGEC	-0.010***	-0.008***	-0.018***	-0.010***	-0.008***	-0.018***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Diarrhoea	-0.126	0.025	-0.170	-0.147	0.015	-0.174
	(0.100)	(0.144)	(0.132)	(0.095)	(0.133)	(0.124)
MOTLIVEH	-0.186***	-0.050	-0.029	-0.146***	-0.028	-0.026
	(0.071)	(0.096)	(0.092)	(0.038)	(0.099)	(0.093)
FATLIVEH	0.055	0.097	0.155	0.066	0.077	0.227
	(0.135)	(0.171)	(0.154)	(0.137)	(0.184)	(0.172)
FatContribute	0.173**	-0.019	0.123	0.167**	-0.011	0.122
	(0.069)	(0.094)	(0.090)	(0.070)	(0.095)	(0.089)
Fatliveh*Contribute	-0.058	-0.120	-0.109	-0.094	-0.113	-0.210
	(0.159)	(0.210)	(0.191)	(0.163)	(0.218)	(0.205)
Son/Daughter	0.300***	0.402***	0.096	0.274***	0.404***	0.114
	(0.107)	(0.151)	(0.138)	(0.108)	(0.145)	(0.137)
Other Relative	0.190*	0.397	0.053	0.109	0.372***	0.006
	(0.103)	(0.140)	(0.130)	(0.105)	(0.139)	(0.133)
MaleHH	-0.083	-0.119	-0.074	-0.060	-0.111	-0.065
	(0.071)	(0.095)	(0.092)	(0.078)	(0.101)	(0.098)
AgeHH	0.039***	0.039**	0.011	0.036***	0.041**	0.006
	(0.010)	(0.015)	(0.014)	(0.012)	(0.016)	(0.015)
AgeHHSQ	-0.000***	-0.000*	-0.000	-0.000**	-0.000*	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
MarriedHH	0.147**	0.187*	-0.007	0.127	0.178*	-0.019
	(0.070)	(0.096)	(0.088)	(0.077)	(0.099)	(0.097)
EDUH	0.029***	0.028***	0.025***	0.035***	0.029***	0.028***
	(0.007)	(0.009)	(0.009)	(0.008)	(0.010)	(0.010)
Children <1 year	0.130**	-0.066	0.139*	0.130*	0.072	0.165*
	(0.062)	(0.087)	(0.083)	(0.073)	(0.093)	(0.091)
Children 1-3 years	-0.158***	-0.231***	-0.012	-0.187***	-0.230***	-0.042
	(0.039)	(0.050)	(0.050)	(0.046)	(0.058)	(0.057)
Children 4-5 years	-0.022	0.032	-0.031	-0.022	0.035	-0.018
	(0.038)	(0.049)	(0.045)	(0.042)	(0.053)	(0.052)
Rural	-0.173***	-0.001	-0.092	-0.143**	-0.005	-0.073
	(0.058)	(0.077)	(0.074)	(0.064)	(0.082)	(0.080)
Log likelihood				-6427.646	-6307.322	-5729.599
LR Chi2				150.80	100.53	134.03
Prob>Chi2				0.000	0.000	0.000
Observations	3481	3013	2863	3481	3013	2863

*, **, *** significant at 10, 5 and 1 per cent respectively. Standard Errors are in parenthesis

We also consider the effect of the age structure of children aged 5 years and below. This we do by controlling specifically for the number of children who are infants (aged less than 1 year), aged 1-3 and those aged 4-5 years. Since these variables may correlate with household size, we leave out the latter in the estimation. Table 8 shows that the number of children in the age 0-1 is positively associated with weight for age and weight for height. On the other hand, the number of children aged 1-3 years is negatively associated with weight for age and height for age. This suggests that competition for resources is introduced by those aged 1-3, while relatively younger ones benefit. Our results could alternatively be explained by the possibility that children in the 0-1 age category are likely to be still breastfed, leaving other resources for older children.

Table 9 presents results for the sub-sample of children who resided with their mothers in the household. A negative association with other (compared to the first) birth orders and child age with child nutritional indicators is found. Compared to children whose mothers have junior secondary education (reference category), pre-primary education is negatively associated with weight for age and height for age, while post-secondary education is positively associated with child weight for age. This suggests that child nutrition is likely to improve with mother`s education. Married mothers and mother`s age are positively associated with weight for age and height for age. The positive effect of mother’s age may signal experience gained for child health production as mothers age, although there appears to be a pattern for an inverted U shape relationship.

We also investigate the effect when mothers are heads of household, captured by a dummy variable. However, we maintain that mothers not residing with children are less likely to be heads. This is because, even though some mothers were not residing with their children in households, we have information for all heads as household residents. Moreover, data shows that none of the children`s absent mothers were reported as heads of households. Nonetheless, a consideration of the entire sample of children reveals that although this variable carries a positive sign in all the nutritional indicators, it is not statistically significant. Similarly, it is insignificant in the subsample of those children residing with mothers. With regards to the latter, several possibilities emerge. When we cross examine the incidence of married mothers with both household headship and the presence of the father, we conclude that mothers are likely to be household heads when unmarried and in the absence of the father. Since children of married mothers have better nutrition, this suggests that the effect outweighs that of mother`s household headship status.

Table 9: OLS and Random Effect Regression for Children residing with their biological mothers

	OLS			**Random Effect**		
Independent Variables	**WAZ (1)**	**HAZ (2)**	**WHZ (3)**	**WAZ (4)**	**HAZ (5)**	**WHZ (6)**
BO2	-0.255**	-0.112	-0.196	-0.237**	-0.100	-0.224
	(0.112)	(0.158)	(0.146)	(0.105)	(0.154)	(0.141)
BO3	-0.391***	-0.058	-0.468**	-0.353**	-0.029	-0.498***
	(0.139)	(0.191)	(0.181)	(0.136)	(0.194)	(0.179)
BO4	-0.547***	-0.474**	-0.260	-0.504***	-0.470**	-0.244
	(0.139)	(0.197)	(0.178)	(0.136)	(0.193)	(0.179)
MaleC	-0.244**	-0.010	-0.146	-0.238**	-0.017	-0.170
	(0.107)	(0.156)	(0.145)	(0.101)	(0.145)	(0.135)
BO2*MaleC	0.077	-0.318	0.314	0.099	-0.333	0.346*
	(0.159)	(0.230)	(0.213)	(0.152)	(0.219)	(0.202)
BO3*MaleC	0.267	-0.020	0.249	0.266	-0.076	0.285
	(0.191)	(0.254)	(0.249)	(0.176)	(0.254)	(0.234)
BO4*MaleC	0.300*	-0.012	0.085	0.314*	-0.014	0.084
	(0.171)	(0.230)	(0.214)	(0.162)	(0.233)	(0.213)
AGEC	-0.012***	-0.006**	-0.021***	-0.011***	-0.006***	-0.021***
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Diarrhoea	-0.144	-0.009	-0.140	-0.183*	-0.021	-0.158
	(0.108)	(0.158)	(0.153)	(0.107)	(0.154)	(0.143)
FATLIVEH	-0.142	-0.044	0.103	-0.033	-0.050	0.099
	(0.193)	(0.222)	(0.243)	(0.205)	(0.280)	(0.262)
FatContribute	0.092	-0.047	0.059	0.108	-0.043	0.067
	(0.084)	(0.117)	(0.110)	(0.085)	(0.117)	(0.110)
Fatliveh*FatContribute	0.126	0.036	-0.065	0.023	0.028	-0.072
	(0.215)	(0.256)	(0.271)	(0.227)	(0.310)	(0.289)
Son/Daughter	0.072	0.061	0.037	0.055	0.076	0.049
	(0.096)	0.137	(0.125)	(0.104)	(0.139)	(0.133)
Other Relative	0.147	0.176	0.248*	0.132	0.175	0.192
	(0.111)	(0.157)	(0.140)	(0.116)	(0.155)	(0.150)
Pre-Primary	-0.241***	-0.214*	-0.120	-0.211**	-0.199*	-0.151
	(0.086)	(0.113)	(0.109)	(0.088)	(0.120)	(0.113)
Post-Junior Secondary	0.148*	0.086	0.116	0.131	0.074	0.094
	(0.078)	(0.108)	(0.103)	(0.081)	(0.112)	(0.106)
Mother Married	0.271***	0.335***	0.019	0.272***	0.313**	0.049
	(0.093)	(0.127)	(0.118)	(0.098)	(0.132)	(0.126)
Mother Age	0.096**	0.083*	0.044	0.096***	0.085*	0.050
	(0.041)	(0.048)	(0.039)	(0.032)	(0.044)	(0.042)
Mother Age squared	-0.001*	-0.001	-0.000	-0.001***	-0.000	-0.001
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)
HHSIZE	-0.009	-0.010	0.001	-0.015	-0.006	-0.002
	(0.012)	(0.017)	(0.016)	(0.014)	(0.018)	(0.017)
Rural	-0.151**	-0.039	-0.058	-0.128*	-0.039	-0.042
	(0.067)	(0.092)	(0.086)	(0.073)	(0.096)	(0.092)
Log likelihood				-4908.869	-4779.608	-4316.238
Chi^2				123.12	57.44	107.78
Prob> Chi^2				0.000	0.000	0.000
Observations	2644	2254	2135	2644	2254	2135

*, **, *** significant at 10, 5 and 1 per cent respectively. Robust Standard Errors are in parenthesis

Table 10: Probit Regression for Children residing with their biological mothers

Independent Variables	**Underweight (1)**	**Stunting (2)**	**Wasting (3)**
BO2	0.047*	0.034	0.008
	(0.026)	(0.035)	(0.026)
BO3	0.071**	0.061	0.017
	(0.032)	(0.044)	(0.031)
BO4	0.079**	0.067	0.002
	(0.031)	(0.042)	(0.032)
MaleC	0.060**	0.015	0.019
	(0.024)	(0.032)	(0.025)
BO2*MaleC	-0.029	0.105**	-0.018
	(0.036)	(0.048)	(0.037)
BO3*MaleC	-0.019	0.050	0.009
	(0.040)	(0.058)	(0.041)
BO4*MaleC	-0.087**	0.027	-0.026
	(0.038)	(0.051)	(0.038)
AGEC	0.000	0.003***	0.000
	(0.000)	(0.001)	(0.000)
Diarrhoea	0.031	0.020	0.010
	(0.023)	(0.032)	(0.025)
FATLIVEH	0.021	-0.020	0.028
	(0.041)	(0.059)	(0.042)
FatContribute	-0.009	-0.006	0.001
	(0.018)	(0.025)	(0.019)
Fatliveh*FatContribute	-0.029	-0.005	-0.054
	(0.046)	(0.065)	(0.047)
Son/daughter	-0.002	-0.007	-0.005
	(0.021)	(0.029)	(0.021)
Other relative	-0.013	-0.017	-0.052*
	(0.024)	(0.032)	(0.027)
Pre-Primary	0.044**	0.070***	0.028
	(0.018)	(0.024)	(0.018)
Post-Junior Secondary	-0.025	-0.044*	-0.017
	(0.018)	(0.024)	(0.018)
Mother Married	-0.048**	-0.046	0.013
	(0.022)	(0.029)	(0.021)
Mother Age	-0.007	-0.017*	0.006
	(0.007)	(0.009)	(0.007)
Mother Age squared	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
HHSIZE	0.002	0.005	-0.001
	(0.003)	(0.004)	(0.003)
Rural	0.024*	0.017	0.006
	(0.014)	(0.020)	(0.015)
Log likelihood	-1080.556	-1312.462	-783.299
Chi^2	64.49	111.06	19.42
Prob>Chi^2	0.000	0.000	0.558
Observations	2644	2254	2135

*, **, *** significant at 10, 5 and 1 per cent respectively. Robust Standard Errors are in parenthesis

5.1 Robustness Checks

A major critique of the random effect model relates to its exogeneity assumption between residual and observable covariates, which has resulted in fixed effect models being considered as a default (Bell and Jones, 2015). Although fixed effects is generally preferred, its application in our context would be to consider a within estimator approach, which involves taking differences on child characteristics within household (Horton, 1988). We therefore compute the household mean values for child characteristics, obtain deviations from their mean and run regressions. In this case the dependent variables are the mean deviations of child nutritional status. We compare the results with those for which the only considered households are those with at least two children. As Table A1 shows, in the within estimator approach child age and sex are significant. On the other hand, Table A2 shows that results are largely similar to the previous ones. We caution that our within estimator results need careful interpretation, as they may be sensitive to the sample size. Unlike Horton (1988)[7] who maintains that this was not a problem in the case of Philippines as less than 10 per cent of families had one child, whereas about 39 per cent of our children come from households with one child and the majority of others have two children.

An alternative approach is the within-between effect model of Bell and Jones (2015), which accounts for the two effects. Unlike fixed effect which only considers the within effects, their (random effect) approach encompasses a fixed component[8] and deviation of variables from the household mean. Not only does approach address endogeneity, but explores its source(s) as well, motivated by the inadequate attention accorded to the reasons why random effect model assumptions may not hold. Results are presented in Table A3, which shows that as in the previous estimates, high birth order children fare worse than their lower birth order counterparts and household size negatively correlate with weight for age and height for age.

We also estimated regression for the subsamples of infants, those aged 1-3 years and those aged 4-5 years. The pattern for these subsamples is similar to the one previously presented where the age group 1-3 accounts for a relatively larger share of about 35 per cent.

7 She however finds that only deviated sex and squared birth order affected height for age, while weight for height is affected by deviated sex and birth order.

8 It is acknowledged that this component was introduced by Mundlak (1978), who maintained that the choice between fixed and random effect model was arbitrary. While Hausman test is commonly used to aid the choice between the two, Bell and Jones (2015:138) argue that for their approach the test is redundant as it "does not address the decision framework for a wider class of problems"

Regression results are presented in the Annex (Tables A4-A6). Child birth order 4 and above is negatively associated with weight for age for infants and for those aged 1-3 while birth order 3 is negatively associated with weight for age for those aged 1-3. The incident of diarrhoea is negatively associated with weight for age for infants, while father's contribution is positively associated with infants` weight for age. Education of the head of the household is positively associated with weight for age for those aged 1-3 and 4-5 years and height for age for infants and those aged 1-3 years. Household size is negatively associated with weight for age for those aged 4-5 years, height for age for infants and weight for height for those aged 4-5 years. Rural area residence is negatively associated with infants` weight for age as well as for those aged 4-5 years.

As indicated, we also analysed the Botswana Family Health Survey data. Tables B2-B4 present OLS regression results for weight for age, height for age and weight for height z scores respectively. In columns II and III of all the tables, we control for village and district effects respectively. Male child is negatively associated with weight for age and height for age. Child`s age is also negatively associated with all the three indicators. Similarly, the incident of diarrhoea is negatively associated with the three indicators, signifying the effect that illness may have on child nutrition. Ever breastfed children are positively associated with weight for age and weight for height. Compared to those whose mothers/carers have secondary education (reference category), mother`s pre-primary education is negatively associated with child weight for age and height for age. The incidence of sourcing water within the household is positively associated positively with the three child nutritional indicators. Compared to ownership of pit-latrines, ownership of flush toilet has is positively associated child nutrition.

6. Conclusion

In this paper, following the deteriorating child nutritional indicators in Botswana, we investigate factors influencing both child nutrition and the likelihood of child malnutrition at household level. Using the 2009/10 Botswana Core Welfare indicator survey data to explore issues of intrahousehold allocation, we estimate the random effect model, which allows for investigating heterogeneity both across and within households. The issue is investigated within a household framework, motivated by the quantity-quality model. Children of high birth order are likely to fare worse than their lower birth order counterparts in terms of child nutrition as also observed by previous studies (Horton, 1988; Kebede, 2005; Jayachandran and Pande, 2017; Howell, et al. 2016). Age of the child is negatively associated with all the three nutritional indicators and increases the probability of child malnutrition, a pattern observed in previous studies in Botswana (Tharakan and Suchindran, 1999), Kenya (Kabubo-Mariara et al. 2008) and Morocco, where the effect was interpreted to reflect possible effects of child weaning (Glewwe, 1999).

Compared to grandchildren, sons/daughters have better weight for age and height for age, suggesting a possibility that parents are more likely to prefer their biological children. However, children categorised as other relations have better height for age values than grandchildren. These results may indicate an effect of unobserved factors such as parental genetic factors, as observed in Ethiopia by Kebede (2005). However, the difference is not significant in the Probit estimates, so should not be over-interpreted. Educational level, age and marital status of household head affect child nutrition. Given that household heads are not biological parents to all children under consideration, these imply that the generally held assumption underpinning the theory may not hold in the context of Botswana households. Children from larger sized households have lower weight for age and height for age and are more likely to be malnourished. Our results may reflect evidence for the resource dilution hypothesis, which appear to be introduced by intrahousehold allocation. Consideration of child age structure suggests that competition for resources adversely affects those aged 1-3 perhaps because young infants are still breastfed. A different pattern for some countries in Latin America, Asia and Sub Saharan Africa was observed for children aged less than three years (Desai, 1995).

From variance decomposition analysis, there are higher variances across than within households. Moreover, higher variances are unexplained by the observed characteristics. Given that children aged 6 to 60 months are eligible for the government monthly food ration at health facilities and yet child health deteriorating, our results call for efforts to look further into the issue of intrahousehold allocation. This will be to ensure that the program attains its objectives of good nutrition, which is also in line with the country`s national population policy objective of quality life. Such efforts should in detail, consider the characteristics of the father and investigate whether the food package in fact reaches the targeted children.

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Appendix A: Regression Results for Robustness Checks

Table A1: Fixed Effect Regressions

Independent Variables	**WAZ**	**HAZ**	**WHZ**
BO2	-0.010	-0.010	-0.039
	(0.054)	(0.080)	(0.072)
BO3	-0.035	-0.035	-0.163*
	(0.072)	(0.097)	(0.089)
BO4+	-0.022	-0.030	-0.016
	(0.058)	(0.087)	(0.076)
AGEC deviation	-0.007***	-0.015***	-0.018***
	(0.002)	(0002)	(0.002)
Sex deviation	0.017	-0.221**	0.129*
	(0.061)	(0.086)	(0.077)
Diarrhoea deviation	-0.143	-0.178	-0.118
	(0.111)	(0.212)	(0.172)
Motherliveh deviation	0.034	0.148	-0.049
	(0.101)	(0.131)	(0.148)
Fatliveh deviation	-0.098	-0.094	-0.004
	(0.105)	(0.164)	(0.148)
Father Contribute deviation	0.058	0.006	-0.135
	(0.094)	(0.140)	(0.132)
Observations	2043	1711	1610

*, **, *** significant at 10, 5 and 1 per cent respectively. Robust Standard Errors are in parenthesis

Table A2: Regression Results for Child Nutritional Indicators (Excluding One under 5 child Household)

Independent Variables	**WAZ** (1)	**HAZ** (2)	**WHZ** (3)
BO2	-0.073	-0.064	-0.062
	(0.116)	(0.151)	(0.151)
BO3	-0.253	-0.247	-0.131
	(0.156)	(0.205)	(0.205)
BO4+	-0.399***	-0.504***	-0.035
	(0.144)	(0.107)	(0.178)
MaleC	-0.059	-0.259*	-0.295**
	(0.116)	(0.108)	(0.144)
MaleC*BO2	-0.006	-0.009	0.042
	(0.169)	(0.236)	(0.221)
MaleC*BO3	0.070	0.226	0.249
	(0.224)	(0.296)	(0.281)
MaleC*BO4+	0.170	0.245	-0.400*
	(0.192)	(0.248)	(0.234)
AGEC	-0.009***	-0.013***	-0.019***
	(0.002)	(0.003)	(0.003)
Diarrhoea	-0.079	-0.132	-0.108
	(0.126)	(0.182)	(0.171)
MOTLIVEH	-0.074	0.057	-0.020
	(0.089)	(0.122)	(0.118)
FATLIVEH	0.139	0.146	0.155
	(0.173)	(0.228)	(0.216)
FatContribute	0.148*	-0.004	0.012
	(0.087)	(0.115)	(0.110)
FatliveH*FatContribute	-0.199	-0.183	-0.164
	(0.204)	(0.274)	(0.257)
Son/Daughter	0.145	0.310	0.011
	(0.138)	(0.192)	(0.174)
Other Relative	0.336***	0.522***	0.188
	(0.119)	(0.180)	(0.147)
Male HH	-0.023	-0.076	-0.018
	(0.088)	(0.121)	(0.117)
AgeHH	0.040***	0.049**	0.011
	(0.014)	(0.021)	(0.018)
AgeHHSQ	0.000***	0.000*	0.000
	(0.000)	(0.000)	(0.000)
MarriedHH	0.136	0.186	0.000
	(0.089)	(0.126)	(0.114)
EDUHH	0.088	0.027**	0.011
	(0.009)	(0.012)	(0.011)
HHSIZE	-0.025**	-0.054***	0.015
	(0.012)	(0.017)	(0.016)
Rural	-0.240***	-0.075	-0.091
	(0.074)	(0.097)	(0.096)
Observations	2043	1711	1610

*, **, *** significant at 10, 5 and 1 per cent respectively. Robust Standard Errors are in parenthesis

Table A3: Within-Between Effect Regression Results for Child Nutritional Indicators

Independent Variables	**WAZ (1)**	**HAZ (2)**	**WHZ (3)**
BO2	-0.052	-0.045	-0.053
	(0.078)	(0.113)	(0.103)
BO3	-0.162	-0.080	-0.288**
	(0.106)	(0.150)	(0.140)
BO4+	-0.271**	-0.367**	-0.130
	(0.110)	(0.148)	(0.140)
Sex Deviation	-0.010	-0.238**	0.136
	(0.074)	(0.111)	(0.099)
AGEC deviation	-0.008***	-0.013***	-0.019***
	(0.002)	(0.003)	(0.003)
Diarrhoea deviation	-0.127	-0.148	-0.086
	(0.153)	(0.238)	(0.208)
MOTLIVEH deviation	0.058	0.153	-0.032
	(0.122)	(0.182)	(0.157)
FATLIVEH deviation	-0.072	-0.106	-0.007
	(0.135)	(0.202)	(0.176)
FatContribute deviation	0.052	-0.006	-0.133
	(0.113)	(0.172)	(0.148)
Son/Daughter	0.081	0.339*	0.039
	(0.133)	(0.177)	(0.170)
Other Relative	0.236*	0.529**	0.066
	(0.133)	(0.172)	(0.168)
MaleHH	-0.022	-0.114	-0.011
	(0.100)	(0.124)	(0.126)
AgeHH	0.033*	0.054**	0.004
	(0.017)	(0.021)	(0.021)
AgeHHSQ	-0.000*	-0.000**	-0.000
	(0.000)	(0.000)	(0.000)
MarriedHH	0.113	0.233*	-0.073
	(0.107)	(0.132)	(0.134)
EDUHH	0.013	0.028**	0.015
	(0.011)	(0.014)	(0.014)
HHSIZE	-0.031**	-0.056***	-0.016
	(0.015)	(0.018)	(0.019)
Rural	-0.226**	-0.066	-0.083
	(0.068)	(0.109)	(0.110)
Log Likelihood	-3701.481	-3502.614	-3140.499
Chi^2	46.87	72.79	60.77
Prob> Chi^2	0.002	0.000	0.000
Observations	2043	1711	1610

*, **, *** significant at 10, 5 and 1 per cent respectively. Standard Errors are in parenthesis

Table A4: Regression Results for Weight for age Z score

	< 1 year	**1-3 years**	**4-5 years**
BO2	-0.198	-0.024	-0.093
	(0.190)	(0.142)	(0.136)
BO3	-0.136	-0.377*	-0.068
	(0.219)	(0.195)	(0.213)
BO4+	-0.491**	-0.394**	-0.133
	(0.223)	(0.198)	(0.186)
MaleC	-0.232	-0.250*	0.132
	(0.176)	(0.144)	(0.137)
BO2*MaleC	0.148	0.119	-0.184
	(0.265)	(0.215)	(0.212)
BO3*MaleC	0.039	0.343	0.158
	(0.310)	(0.280)	(0.305)
BO4*MaleC	0.096	0.282	0.154
	(0.282)	(0.259)	(0.244)
Diarrhoea	-0.252*	-0.007	0.129
	(0.144)	(0.171)	(0.240)
MOTLIVEH	-0.057	-0.146	-0.158
	(0.165)	(0.113)	(0.120)
FATLIVEH	-0.119	0.071	0.072
	(0.332)	(0.224)	(0.182)
FatContribute	0.272**	0.089	0.136
	(0.133)	(0.113)	(0.115)
FatliveH*FatContribute	-0.219	0.117	-0.049
	(0.370)	(0.258)	(0.235)
Son/Daughter	0.361*	0.072	0.254
	(0.206)	(0.181)	(0.188)
Other relative	0.017	0.097	0.369**
	(0.203)	(0.149)	(0.177)
MaleHH	-0.064	0.065	-0.121
	(0.141)	(0.108)	(0.118)
AGEHH	0.027	0.028	0.057***
	(0.019)	(0.017)	(0.017)
AGEHHSQ	0.000	0.000	-0.000***
	(0.000)	(0.000)	(0.000)
MarriedHH	0.007	0.219**	0.190*
	(0.137)	(0.111)	(0.116)
EDUHH	0.011	0.045***	0.021*
	(0.013)	(0.011)	(0.011)
HHSIZE	-0.025	0.006	-0.067***
	(0.021)	(0.016)	(0.015)
Rural	-0.201**	-0.142	-0.278***
	(0.108)	(0.096)	(0.096)
Observations	1162	1244	1075

*, **, *** significant at 10, 5 and 1 percent; Robust Standard Errors in parenthesis

Table A5: Regression Results for Height for age z scores for the subsamples

	< 1 year	1-3 years	4-5 years
BO2	0.249	-0.012	-0.143
	(0.261)	(0.189)	(0.195)
BO3	0.065	0.155	0.012
	(0.322)	(0.220)	(0.258)
BO4	-0.450	-0.273	-0.185
	(0.285)	(0.252)	(0.258)
MaleC	-0.268	-0.040	-0.042
	(0.258)	(0.187)	(0.173)
BO2*MaleC	-0.249	-0.265	-0.265
	(0.390)	(0.277)	(0.294)
BO3*MaleC	0.151	0.109	-0.017
	(0.464)	(0.332)	(0.368)
BO4*MaleC	0.229	0.022	0.191
	(0.412)	(0.322)	(0.306)
Diarrhoea	-0.058	0.350	0.134
	(0.217)	(0.233)	(0.318)
MOTLIVEH	0.594***	-0.330**	-0.062
	(0.219)	(0.150)	(0.158)
FATLIVEH	-0.464	0.099	0.391*
	(0.444)	(0.261)	(0.258)
FatContribute	-0.069	-0.013	-0.060
	(0.194)	(0.141)	(0.150)
FatliveH*FatContribute	0.094	-0.001	-0.231
	(0.503)	(0.320)	(0.318)
Son/Daughter	0.449	0.129	0.352
	(0.304)	(0.249)	(0.255)
Other Relative	0.276	0.233	0.375
	(0.283)	(0.199)	(0.233)
MaleHH	0.043	0.028	-0.260*
	(0.196)	(0.145)	(0.152)
AGEHH	0.037	0.031	0.036
	(0.031)	(0.024)	(0.023)
AGEHHSQ	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)
MarriedHH	0.084	0.241*	0.175
	(0.194)	(0.144)	(0.160)
EDUHH	0.056***	0.017	0.021
	(0.019)	(0.015)	(0.015)
HHSIZE	-0.052*	-0.026	-0.025
	(0.027)	(0.021)	(0.020)
Rural	-0.021	0.057	-0.182
	(0.157)	(0.116)	(0.124)
Observations	953	1075	985

*, **, *** significant at 10, 5 and 1 percent; Robust Standard Errors in parenthesis

Table A6: Regression Results for Weight for height z scores for the subsamples

	< 1 year	**1-3 years**	**4-5 years**
BO2	-0.342	-0.043	-0.225
	(0.236)	(0.193)	(0.189)
BO3	-0.377	-0.425*	-0.311
	(0.310)	(0.242)	(0.291)
BO4	-0.148	-0.190	-0.084
	(0.269)	(0.233)	(0.241)
MaleC	-0.146	-0.016	0.234
	(0.229)	(0.188)	(0.161)
BO2*MaleC	0.499	0.101	0.357
	(0.349)	(0.282)	(0.284)
BO3*MaleC	0.037	0.210	0.177
	(0.434)	(0.346)	(0.373)
BO4*MaleC	-0.102	-0.020	-0.208
	(0.370)	(0.307)	(0.298)
Diarrhoea	-0.263	-0.238	0.212
	(0.175)	(0.244)	(0.356)
MOTLIVEH	-0.068	-0.009	0.022
	(0.223)	(0.143)	(0.149)
FATLIVEH	0.038	0.256	0.042
	(0.380)	(0.260)	(0.214)
FatContribute	0.192	0.005	0.179
	(0.177)	(0.146)	(0.171)
FatliveH*FatContribute	-0.049	-0.202	0.030
	(0.439)	(0.315)	(0.285)
Son/Daughter	0.179	0.185	-0.120
	(0.276)	(0.219)	(0.229)
Other relative	-0.119	-0.137	0.105
	(0.259)	(0.204)	(0.208)
MaleHH	-0.198	-0.006	-0.016
	(0.187)	(0.144)	(0.157)
AGEHH	0.001	-0.004	0.037*
	(0.028)	(0.021)	(0.021)
AGEHHSQ	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)
MarriedHH	-0.039	0.034	-0.020
	(0.175)	(0.137)	(0.153)
EDUHH	0.032*	0.029**	0.010
	(0.018)	(0.015)	(0.014)
HHSIZE	0.015	0.025	-0.036*
	(0.025)	(0.021)	(0.020)
Rural	-0.049	-0.080	-0.143
	(0.144)	(0.118)	(0.118)
Observations	881	1057	931

*, **, *** significant at 10, 5 and 1 percent; Robust Standard Errors in parenthesis

Appendix B: Summary Statistics and Regression Results from the 2007/08 BFHS Data

Table B1: Summary Statistics from BFHS data

Variable	Mean	Std. Dev.
Dependent		
WAZ	-0.729	1.262
HAZ	-1.067	1.625
WHZ	-0.031	1.484
Independent		
Child Characteristics		
MaleC	0.504	0.500
AGEC	28.926	16.722
Diarrhoea	0.094	0.292
Breastfed	0.763	0.426
Rural	0.499	0.500
Household Characteristics		
Mother Age	33.441	12.546
No Education	0.130	0.337
Primary	0.271	0.445
Secondary	0.584	0.493
Non-Formal	0.013	0.112
Piped indoors	0.154	0.361
Tap in yard	0.412	0.492
Communal tap	0.305	0.460
Bouser/Tanker	0.004	0.062
Well	0.016	0.125
Borehole	0.051	0.219
River/stream	0.014	0.115
Dam	0.006	0.078
Rainwater tank	0.001	0.034
Bottled water from stores	0.005	0.071
Neighbours	0.033	0.179
Own Flush toilet	0.171	0.377
Own Ventilated Improved Pit latrine	0.198	0.399
Own Pit latrine	0.312	0.463
Own Environment loo	0.002	0.048
Communal flush toilet	0.003	0.055
Communal Ventilated Improved Pit latrine	0.003	0.052
Communal pit latrine	0.028	0.165
Neighbour’s toilet	0.043	0.203
No Toilet	0.238	0.426

Source: author`s computation from BFHS data

Table B2: Regression results for Weight for age z scores from BFHS Data

Variable	I (Baseline)	II (Village Effect)	III (District Effect)
MaleC	-0.084*	-0.092***	-0.079**
	(0.048)	(0.033)	(0.036)
AGEC	-0.014***	-0.014***	-0.014***
	(0.002)	(0.001)	(0.001)
Diarrhoea	-0.387***	-0.396***	-0.393***
	(0.082)	(0.070)	(0.061)
Breastfed	0.140**	0.149***	0.144**
	(0.058)	(0.050)	(0.062)
Rural	-0.059	-0.019	-0.061
	(0.058)	(0.065)	(0.092)
Mother Age	0.004*	0.004***	0.004
	(0.002)	(0.002)	(0.003)
Pre-Primary	-0.131**	-0.129**	-0.117
	(0.063)	(0.053)	(0.095)
Fatliveh	-0.071	-0.079***	-0.071
	(0.049)	(0.026)	(0.048)
Water indoors	0.271***	0.235***	0.278***
	(0.066)	(0.058)	(0.065)
Own flush toilet	0.409***	0.394***	0.421***
	(0.076)	(0.044)	(0.103)
No toilet	0.010	0.023	0.016
	(0.076)	(0.076)	(0.101)
Other toilet	-0.021	-0.016	-0.012
	(0.086)	(0.097)	(0.017)
HHSZ	-0.010	-0.007	-0.012
	(0.007)	(0.006)	(0.008)
Observations	2524	2524	2524

*, **, *** significant at 10, 5 and 1 per cent; Robust Standard Errors in parenthesis. Standard errors for village and district effects are clustered at village and district level respectively

Table B3: OLS Regression results for Height for age z scores from BFHS Data

Variable	I (Baseline)	II (Village Effect)	III (District Effect)
MaleC	-0.218***	-0.219***	-0.223***
	(0.064)	(0.057)	(0.055)
AGEC	-0.007***	-0.007***	-0.007***
	(0.002)	(0.002)	(0.002)
Diarrhoea	-0.345***	-0.360***	-0.321***
	(0.116)	(0.111)	(0.113)
Breastfed	0.080	0.080	0.083
	(0.080)	(0.074)	(0.093)
Rural	-0.051	-0.058	-0.046
	(0.085)	(0.099)	(0.123)
Mother Age	0.004	0.004	0.004
	(0.003)	(0.003)	(0.004)
Pre-Primary	-0.240***	-0.229***	-0.228*
	(0.080)	(0.056)	(0.113)
Fatliveh	0.001	0.000	0.007
	(0.065)	(0.058)	(0.068)
Water Indoors	0.233**	0.180**	0.220**
	(0.092)	(0.079)	(0.095)
Own flush toilet	0.377***	0.382***	0.331***
	(0.095)	(0.065)	(0.114)
No toilet	0.050	0.053	0.095
	(0.104)	(0.105)	(0.112)
Other toilet	-0.158	-0.179	-0.137
	(0.122)	(0.125)	(0.148)
HHSZ	-0.023**	-0.016	-0.025*
	(0.009)	(0.010)	(0.014)
Observations	2524	2524	2524

*, **, *** significant at 10, 5 and 1 per cent; Robust Standard Errors in parenthesis. Standard errors for village and district effects are clustered at village and district level respectively

Table B4: OLS Regression results for Weight for height z scores from BFHS Data

Variable	I (Baseline)	II (Village Effect)	III (District Effect)
MaleC	-0.032	-0.044	-0.021
	(0.057)	(0.043)	(0.045)
AGEC	-0.025***	-0.024***	-0.025***
	(0.002)	(0.002)	(0.002)
Diarrhoea	-0.187*	-0.187**	-0.209
	(0.103)	(0.083)	(0.129)
Breastfed	0.123*	0.135**	0.124
	(0.070)	(0.054)	(0.091)
Rural	0.005	0.060	-0.034
	(0.074)	(0.073)	(0.108)
Mother Age	0.002	0.002	0.002
	(0.003)	(0.002)	(0.003)
Pre-Primary	0.042	0.030	0.052
	(0.074)	(0.056)	(0.079)
FATLIVEH	-0.096*	-0.108**	-0.087
	(0.058)	(0.048)	(0.060)
Water Indoors	0.192**	0.185**	0.209**
	(0.082)	(0.077)	(0.072)
Own flush toilet	0.273***	0.255***	0.337**
	(0.091)	(0.051)	(0.119)
No toilet	-0.050	-0.023	-0.077
	(0.090)	(0.109)	(0.120)
Other toilet	0.078	0.101	0.066
	(0.108)	(0.139)	(0.110)
HHSZ	0.002	-0.00	0.002
	(0.009)	(0.007)	(0.009)
Observations	2524	2524	2524

*, **, *** significant at 10, 5 and 1 per cent; Robust Standard Errors in parenthesis. Standard errors for village and district effects are clustered at village and district level respectively.