Determinants of Undernutrition in Under-five Children: Evidence from the 2015 Zimbabwe Demographic and Health Survey

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Abstract

Health is essential to a successful and productive life at all stages. Early good child health is also believed to shape the future productivity levels of every individual. Using height-for-age z scores, this study used an ordered logistic regression model to estimate the determinants of undernutrition in children under the age of five in Zimbabwe. Data from the Zimbabwe Demographic and Health survey of 2015 was used. The study finds that factors such as safe drinking water, improved toilet facility, tertiary-level maternal education, longer birth interval, and clean cooking power: all contributing to a child having good nutrition stock. More so, the study finds factors such as being a male child and urban residence contributing to poor nutrition of children under the age of five. Hence, the study advocates that improving water and toilet facilities, improving maternal education, using birth control measures and using clean energy will go a long way in improving the nutrition of children under the age five in Zimbabwe.

1. Introduction and Motivation

Children of today are the leaders of tomorrow. This means the health and quality of the future economy are, to some extent, reflected by the ‘quality’ and health of today’s children. One can easily argue that to build a strong future economy we must start by taking care of children. More so, together with women and the disabled, children are considered the most vulnerable members of the community (Becker, 1993; UNICEF, 2019). Hence, the health of children reflects not only the ‘quality’ of children themselves, but also the current ‘quality’ and welfare of the entire community (Becker & Barro, 1986; Becker, 1993; Charmarbagwala et al., 2012; de Onis et al., 2004; Development Initiatives, 2018). Yet, the health of children under-five years, particularly in developing countries, has been negatively affected by high mortality risks and undernutrition problems (Development Initiatives, 2018; UNICEF, 2019; World Bank, 2006).

Globally, it is estimated that millions of children under-five years of age die, mostly from preventable causes such as pneumonia, diarrhoea, and malaria (UNIGME, 2017). In many developing countries, undernutrition alone accounts for around 45% of these deaths; while unsafe water, sanitation, and hygiene are also significant contributing factors (Development Initiatives, 2018). With the introduction of the Sustainable Development Goals (SDGs)[1] in 2015, and the UN Decade of Action on Nutrition (2016–2025) goals, the health of children under the

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[1] The successor to the Millennium Development Goals (MDGs).

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age of five also became a good measure of the track of the progress towards the attainment of these goals, since most of these are centred on the above-mentioned problems. This is reflected by the link between SDG 2 target for child malnutrition,[2] SDG 3 target for child mortality,[3] and the rest of the SDGs.

At the individual level, a person is predicted to have a better life ahead of her/him if s/he survive earlier years of life well-nourished and healthy (Rabbani & Qayyum, 2015; Caulfield et al., 2004; Frongillo & Pelletier, 2003; UNICEF Zimbabwe, 2016). At the macro level, a healthy child is an asset to any country, as s/he represents a strong future human capital. Coupled with the fact that every human being (children included) has a moral right to a healthy life,[4] improvement in the health of children and the reduction of their mortality rate become not only an economic duty, but also a moral duty for policymakers (Grantham-McGregor et al., 2007; Becker, 1993).

Yet, when it comes to the health of children under-five in Zimbabwe, long-standing problems of undernutrition and high mortality risks have refused to go away despite increased efforts by the government, and its development partners, to eradicate them (FNC, 2018). Undernutrition also impacts negatively on a child's development, thereby compromising the immune system, increasing susceptibility to diseases, and restricting the attainment of human potential (FNC, 2018; UNICEF, 2015). Yet the country has 26.2% of the children under-five years suffering from undernutrition (ZNSA & ICF International, 2016). Not only is this figure among the highest in the world, but it is also above the UN global target of less than 20% (Development Initiatives, 2018).

Given the strong link between the health of children, individual cognitive development, and community prosperity highlighted above, together with the gap in literature, it is important to have a deeper understanding of why children are unlikely to have good health in their early years of life; years that are very sensitive, delicate, and future-shaping for every human being. The aim is to find long-lasting solutions to the problems of malnutrition in Zimbabwe and other developing countries.

2. Overview of Child Nutrition in Zimbabwe

On the global level, children under-five years of age face multiple nutrition burdens: 150.8m (22.2%) are stunted, 50.5m (7.5%) are wasted, and 38.3m (5.6%) are overweight (Development Initiatives, 2018). Meanwhile, the 2018 Global Nutrition Report has also reported that 20m babies are born with a low birth weight each year. These problems continue to exist despite global efforts to end them (Development Initiatives, 2018; UNICEF, 2019).

[2]SDG 2 aims to end hunger, achieve food security and improved nutrition and promote sustainable agriculture. Target 2.2 aims to end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age by 2030.

[3]SDG 3 aims to ensure healthy lives and promote wellbeing for all at all ages. Target 3.2 aims to end preventable deaths of new-born and children under 5 years of age by 2030

[4]In Zimbabwe, this is enshrined in Section 76 of the constitution.

Moreover, whilst stunting prevalence in Zimbabwe has declined from 33% in 2010 to 26% in 2018, it remains above the acceptable global threshold of 20% (FNC, 2018; ZNSA & ICF International, 2016; Development Initiatives, 2018). Furthermore, 35 districts are above the national average of 26%, while 14 districts are in the high prevalence category according to the WHO classifications (30–39%). Hence, stunting reduction programs need to be scaled up to accelerate the attainment of the Malabo declaration target of 20% or less by 2025 across all the country's districts (ZNSA & ICF International, 2016; Development Initiatives, 2018).

On the other hand, the current prevalence of wasting (2.5%) is within the acceptable WHO cut-off values for public health action. However, some districts have prevalence above the national average. These include districts in Matabeleland South and Manicaland provinces.

The current national prevalence of underweight is 8.8%, and remains acceptable based on the WHO threshold of below 10% (Table 1). It is also lower than the combined Southern Africa region figure of 12.7%. However, it is worth pointing out that evidence from the 2015 Zimbabwe Demographic and Health Survey (ZDHS) showed that 14 districts are in the medium prevalence of 10–19% (ZNSA & ICF International, 2016). Thus, the government of Zimbabwe needs to focus on interventions that reduce and maintain underweight rates below global thresholds in all the country's districts (ZNSA & ICF International, 2016).

Table 1: Triple Burden of Malnutrition in Zimbabwe

Region/ Country	Stunting (%)	Wasting (%)	Underweight (%)
Zimbabwe (2018)	26.2	2.5	8.8
Southern Africa (2019)	29.0	3.3	12.7
Global Targets	< 20	< 5	< 10

Source: 2018 ZNNS, 2018 Global Nutrition Report and UNICEF, WHO, World Bank 2019.

Stunting generally tends to increase with a child's age, with data from the 2015 ZDHS showing that it increased from 13% in children aged 6–8 months, to a peak of 39% children aged 24–35 months; before declining to 18% of children aged 48–59 months (ZNSA & ICF International, 2016). Additionally, stunting varies with gender: with boys having a higher proportion of stunting than girls (30% versus 24%). Evidence from the 2015 ZDHS shows that all the three measurements of undernutrition are higher in rural areas than in urban areas, whereas the proportion of overweight children is higher in urban areas than in rural areas (Development Initiatives, 2018; FNC, 2018; ZNSA & ICF International, 2016).

The survey also finds that the prevalence of stunting is highest among children whose mothers have no education (45%), and lowest among children whose mothers have more than secondary education (9 percent) (FNC, 2018; ZNSA & ICF International, 2016). In contrast, the prevalence of overweight is lowest among children whose mothers have no education (3%), and highest among those whose mothers have more than secondary education (9%) (ZNSA & ICF International, 2016).

3. Literature Review and Conceptual Framework

3.1 Literature Review

This subsection outlines the empirical literature of studies that tried to find factors that affect malnutrition in children under the age of five in different parts of the world, particularly in developing countries. This literature varies again in terms of the data and methodologies used.

Makoka (2013) studied the impact of maternal education on child nutrition in three different countries: Malawi, Tanzania, and Zimbabwe. The author used the DHS data of 2010 for Malawi; 2009–10 DHS data for Tanzania; and the 2005–06 DHS data for Zimbabwe. Logistic regression was employed to assess the determinants of the three measures of malnutrition (i.e., stunting, wasting, and underweight), placing focus on maternal education. He found out that in the three countries, the three measures of malnutrition significantly decrease with increased levels of maternal education. After controlling for other factors, maternal education reduced the odds of all three measures of child malnutrition in all the three countries (ibid.). The threshold level of maternal education above which it significantly improved child stunting and underweight were 9 years in Malawi, and 11 years in Zimbabwe and Tanzania. The author advocated for more educational incentives for women, since the current free primary education being offered in the three countries may not be sufficient to address child malnutrition (ibid.).

Poda et al (2017) studied factors associated with under-five malnutrition in Burkina Faso, using the 2010 DHS data of the country. Both multivariate and bivariate methods were used for analysis. Child sex, age, size at birth, child morbidity, mother's education, body mass index and household wealth index were significantly associated with undernutrition among children under-five years in Burkina Faso (ibid.). The study recommended that, in addition to the improvement of household wealth index, more health and nutritional education for mothers should be implemented by the government to improve the health and nutritional status of children under 5 years in Burkina Faso (ibid.). This research concurred with the one done by Makoka (2013) on the issue of maternal education and malnutrition in children under the age of five, even though the researches were done in different countries and used different methodologies.

Furthermore, Sondai et al. (2017) made a research on the same topic in Yemoh town, in the city of Bo, Southern Sierra Leone. The researchers collected primary data, and used primary descriptive statistics to analyse the data. The population comprised all under-five children and their lactating mothers or caregivers, and a sample of 100 under-five children and 100 lactating mothers selected from the Yemoh town community. The study revealed that 48% of the sampled under-fives were malnourished children; and out of this percentage, 55% were females (ibid.). The findings also revealed that the demographic factor associated with the malnutrition of under-five children in the community was age distribution of the mother at birth. The socioeconomic factors included education of the mother, number of meals taken by the child per 24 hours, breastfeeding practices, household's employment status, alcohol intake by respondent mother/caregiver, and parent's marital status. Also, the health-related factors were antenatal clinic consultation (ANC), immunization status, vitamin A supplementation, and institution where a child was delivered. In the end they recommended that increasing household food security and reinforcing educational intervention could contribute to the reduction in the prevalence of malnutrition of under-five children in the communities.

Moreover, a number of studies were also carried out using the logistic regression model in several parts of the world (Sazedur et al., 2017; Gowranga et al., 2018; Mishra et al., 2014; Adhikari et al., 2019; Talukder, 2017). In Bangladesh, the results from a research by Talukder (2017) strongly highlighted the necessity of increasing maternal education level, improving maternal nutritional status, and increasing facilities providing antenatal care services to achieve better nutrition status among under-five aged children. The research from Nepal by Adhikari et al. (2019) reveals that household wealth status, age of child, size of child at time of birth, and child anaemia comprised the common determinants of stunting in all three surveys in the area. The study findings underscored the need for effective implementation of evidence-based nutrition interventions in health and non-health sectors to reduce the high rates of child stunting in Nepal. The same results were found in India by Mishra et al. (2014), who revealed that for children suffering from acute malnutrition, maternal nutritional status was the most dominant factor; followed by child's age, maternal education, wealth index, type of tribe and size of child at birth (ibid.).

3.2 Conceptual Framework

Economic analysis of child health is empirically linked to classical household models, healthcare demand and production models, nutrition provision models, and fertility models; where a household's utility is maximized subject to resource constraints. The application of these models is ultimately related to choices made in respect of some investment decisions, which also explain trade-offs between the number of children and the ability to raise them qualitatively (Becker & Barro, 1986; Becker, 1965, 1993; Becker & Lewis, 1973). However, this study adopted the UNICEF framework.

The UNICEF framework incorporates both socioeconomic and biological determinants, and encompasses causes at both macro and micro levels. In this framework, there is a sequence of events that will determine the health of a child. At the bottom of this sequence are basic determinants, and these affect underlying determinants. In turn, the underlying determinants will affect immediate determinants; and it is these immediate determinants that will eventually impact the health of a child (Scrimshaw et al., 1968; UNICEF, 2015; Smith & Haddad, 1999). The sequence of events in this framework is shown in Figure 1.

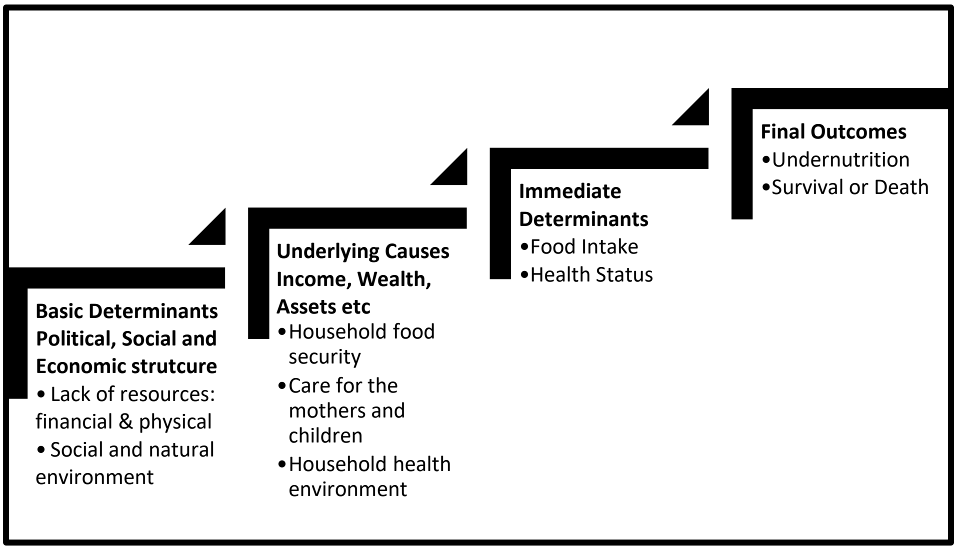

Figure 1: UNICEF Conceptual Framework
Source: UNICEF 1998, 2015. Modified by the author to suite the study.

3.2.1 Basic Determinants
These are recognized at the country or community level. They include the potential resources available to a country or community, which are limited by the natural environment, access to technology, and quality of human resources. Political, economic, cultural, and social factors affect the utilization of these potentials and how they are translated into resources for food security, care, and healthy environments and services. These social, economic and political factors can have long-term influence on child health, increasing the risk of mortality and undernutrition (World Bank, 2006).

3.2.2 Underlying Determinants
These manifests themselves at the household level and they include food security, adequate care for the child and the childcare giver; and proper health environment, including access to health services. Associated with each is a set of necessary resources for their achievement. Food security is achieved when an individual has enough food for an active and healthy life. Resources necessary for achieving food security include food stock, and income for food purchases, among others. No child can grow without the nurturing of another individual being. In this framework, the child-caregiver is assumed to be the mother. Therefore, the framework advocates for the care of both the child and the mother.

Health environment and services is also another underlying determinant; and rests on the availability of safe water, sanitation, and healthcare environment. Anchoring all these underlying determinants is poverty. A person is in poverty when s/he cannot afford his/her basic needs. The effects of poverty on child health are pervasive. Poor families are unable to achieve food security, have inadequate resources for childcare, and are unable to afford healthcare products and services.

3.2.3 Immediate Determinants

These manifests themselves at the individual human being level. They include dietary intake (for example, nutrients consumption) and health status. A child with inadequate dietary intake is more susceptible to diseases. In turn, diseases depress appetite, inhibit the absorption of nutrients in foods, and compete for the child's energy, which leads into more child health problems. Dietary intake must also be adequate in quantity and quality, and nutrients must be consumed in appropriate combinations for the human body to be able to absorb them (Scrimshaw et al., 1968; UNICEF, 2015; World Bank, 2006).

4. Methodology

4.1 Data and Hypothesis

This study specifically seeks to identify factors that determine the nutrition stock of children under the age of five years in Zimbabwe using the latest ZDHS. As a consequence, the study hypothesizes that family demographics, socioeconomic factors, geographical location, and sanitation conditions (*source of drinking water and toilet facility)* have an impact on child nutrition. More so, child-specific and maternal factors (*child's birth order, preceding birth interval, maternal age, maternal education, child's sex,* and *type of birth*), have an impact on child nutrition.

To achieve the research objective and test the hypotheses stated above, the study used a highly reliable data set: the 2015 ZDHS. This was the latest DHS in the country at the time of the research, and it employed a two-stage cluster sampling technique to select a population representative sample. From the survey, a total of 2,812 children were able to provide the anthropometric measures of their health. This is the sample that was then used in this study. The unit of analysis in the study is children under the age of five in a household.

4.2 Dependent Variables

In this study, stunting is used to measure nutrition stock since children who are stunted are also likely to suffer from weighting and wasting (FNC, 2018; Development Initiatives, 2018). More so, stunting is the biggest problem in the country compared to the other two problems (ZNSA & ICF International, 2016). Stunting in this study is measured using the height-for-age z score (HAZ). HAZ is one of the three anthropometric measures that have been used in literature to assess child health; with the other two being weight-for-age z score (WAZ), and weight-for-height z score (WHZ). HAZ was chosen as a dependent variable in this study given that children who are stunted, as measured by their HAZ score, are also likely to suffer from other malnutrition problems (Development Initiatives, 2018).

Undernutrition will be measured as categorical and ordered from 1 to 3; i.e., severe undernutrition (=1), moderate undernutrition (=2) and good nutrition (=3). This will be a deviation from the traditional way of using these anthropometric measures, in which children are categorised as either being undernourished or not (Development Initiatives, 2018). Since children who are undernourished are either severely undernourished or moderately undernourished, the researcher used this as the first lower categories in categorising the nutrition of children. The advantage of this way of categorisation is that it captures all the categories, rather than suppressing the other categories, when undernutrition is measured in a binary form.

4.3 Explanatory Variables

4.3.1 Maternal Education

This refers to the highest level of education attained by the maternal mother of the child under study. From the dataset of the 2015 ZDHS, this variable was already categorized into four categories: no education, primary education, secondary education, and tertiary education. For this study, however, the variable was recoded to a dummy with 1 representing lower levels of education attainment (no education, primary education and secondary), whilst 0 represents higher level of education (tertiary). This study hypothesized that the higher a mother goes in terms of education, the more likely she can have more resources—both in terms of financial and knowledge—for care-giving purposes (FNC, 2018; UNICEF, 2019). Hence, less child health problems are expected for children born to mothers with higher (tertiary) level education.

4.3.2 Maternal Nutritional Status

A good health of a child starts even before birth. Poor maternal nutrition affects a child while in the womb, and during childbirth (UNICEF, 2019). Hence, the importance of maternal nutrition status in this research as an explanatory variable. Body mass index (BMI) was used to measure this variable. Maternal BMI was computed as weight in kilograms divided by the square of height in meters. BMI cut-offs were based on the recommended international cut-offs: i.e., underweight was defined as BMI<18.5 kg/m^2, normal body weight was defined as BMI 18.5–24.9 kg/ m^2, and overweight and obesity was defined as BMI > 25.0kg/m^2. A dummy variable was then coded; with 1 representing underweight, and 0 representing normal and overweight. This was motivated by the idea that, usually a mother who is undernourished signify the problem of food shortages in the family; whereas the other two categories represents the availability of enough food within the household. Thus, we expect mothers with a normal and/or overweight body weight to report fewer cases of child undernutrition problems compared to mothers who are underweight.

4.3.3 Maternal Age

Biologically, there are certain years in a woman's age where there is an increased probability that a woman will get pregnant. Maternal fertility increases from the first menstrual period, and reaches a peak in the mid- to early 30s. Thereafter, it starts depreciating from the mid-30s, and it is during this period that can lead to child health complications during pregnancy (Sazedur et al., 2017). These complications may negatively affect the health of a child during pregnancy, leading to a child experiencing difficult first five years of her/his life (World Bank, 2006). The variable was coded as a dummy, with 1 representing maternal age of above 35 years, and 0 representing otherwise.

4.3.4 Premature Birth

This is another variable that was included to capture the initial health endowment that a child is born with. According to the WHO, a child is prematurely born if the birth weight is below 2500 grams (ZNSA & ICF International, 2016). Hence, the variable was coded as a dummy, with 1 representing that a child was delivered prematurely (i.e., with birth weight below 2500 grams); and 0 representing otherwise. The *a priori* expectation is that a child who was born prematurely will have tough first years of life, leading to increased health problems.

4.3.5 Single Births

This refers to whether a child was delivered in singleton (=1), or otherwise (=0); and speaks to competition on initial health endowments among children during pregnancy. We expect children who are born in singleton to have no competition on resources during pregnancy, hence less undernutrition problems. On the other hand, we expect a child who was delivered as part of multiple births at once to have more resource competition during pregnancy and after birth, leading to problems such as low birth weight. These in turn may increase undernutrition problems and may cause death (Becker & Tomes, 1976; Becker & Lewis, 1973).

4.3.6 Child's Sex

Sex refers to the gender of a child under study, and it is a dummy variable categorized as male (=1), or female (=0). This variable speaks to the genetic variability between a girl child and a boy child. With the survey data reporting more male children being undernourished compared to female ones, *a priori* expectations were that being a male children was expected to be more undernutritioned compared to female children (ZNSA & ICF International, 2016).

4.3.7 Cooking Fuel

This refers to the type of cooking fuel used, which is either solid fuel (=0) or clean fuel (=1). It speaks of how food is prepared, leading to the quality of nutrients that are eventually consumed (UNICEF, 2015). This also speaks of the availability of financial resources to a household, given that in Zimbabwe clean energy is expensive compared to solid energy since people almost always do not need to pay to get solid fuel, especially firewood, which is the dominant solid fuel in the country. It is unclear whether solid fuels prepare food better compared to clean fuels, or vice versa. What is clear is that households that use clean energy for food preparation are likely to have more financial resources compared to those using solid fuels. Hence, we may expect households using clean energy to report less child undernutrition compared to those using solid fuel.

4.3.8 Residence

This refers to the place in which a child resides. It is categorized as urban (=1), or rural (=0). The fundamental differences in the socio-economic set-up between rural and urban makes this variable important in determining the health of children in these areas (Becker & Lewis, 1973). Poverty levels are relatively high in rural compared to urban areas (UNICEF Zimbabwe, 2016; ZNSA & ICF International, 2016). As such, *a priori* expectation is that there are high cases of undernutrition in rural areas where residents are disadvantaged in terms of their socioeconomic standings, as well as their accessibility to health services compared to urban areas.

4.3.9 Source of Drinking Water

This refers to the source of drinking water used by a household. The guidance of the DHS program put these in two categories: improved water source (=1), and unimproved water source (=0). According to the guidance manual of the DHS Program Statistics, improved water sources include piped, borehole, protected well, protected spring, rainwater, and bottled water. Conversely, unimproved water facilities include unprotected well, unprotected spring, surface water, small cart, tanker truck and others (Croft et al., 2018). Here, the *a priori* expectation is that children whose households use unimproved water sources would experience more malnutrition problems compared to those that use improved sources of water.

4.3.10 Preceding Birth Interval

This refers to the space between one child and the previous one. The standard WHO recommendation for this space is 33 months, which include 24 months since the last child was born, plus a mature pregnancy (9 months) (Development Initiatives, 2018; UNICEF, 2019). The variable was coded as a dummy, with short birth interval (=1), and long birth interval (=0). The *a priori* expectation of the study is that infants given care for a shorter period by their mothers before another sibling is born would have less chances of surviving compared to those who are sparsely distributed. Thus, birth interval was expected to be negatively related to undernutrition.

4.3.11 Religious Background

This refers to the type of religious doctrine that household members of the family to which a child was born; and addresses the beliefs and norms that the parents have about raising children. For this research, this variable was a dummy, with 1 representing those mothers who follow the apostolic sect doctrine, and 0 representing otherwise. This was motivated by the idea that the healthcare seeking behaviour of the apostolic sect doctrine is far inferior compared to other religious doctrines (ZNSA & ICF International, 2016).

4.3.12 Toilet Facility

The physical environment in which mothers live and their children grow up is important in determining their health (Development Initiatives, 2018). In that case, the type of toilet facility used is an important part of sanitation and hygiene. Toilet facility was measured as either an improved source (=1), or an unimproved source (=0); based on the DHS classification method. We expect families using improved sources to report good nutrition for their children, compared to those with unimproved sources.

4.4 Empirical Model

The study employed an ordered logistic regression model, which was more suitable for the research on this question because the dependent variable (i.e., nutrition stock) is a categorical variable; and is ordered from 1 up to 3 as explained in the previous section. In the model, 1 represents extremely bad nutrition stock (severe undernutrition); 2 represents moderately bad nutrition stock (moderate undernutrition); and 3 represents good or acceptable nutrition stock. This model is also known as the proportional odds model because the odds ratio of the event is independent of the category j. The odds ratio is assumed to be constant for all categories.

Our dependent variable is height-for-age z (HAZ) score, Y; which in our case will have three ordered categories. Y is in turn a function of another variable, $\mathbf{Y}^*$, that is not measured; which is called a latent variable. This latent variable is unmeasured and continuous, and its values determine what the values of the ordinal variable, Y, will be. The continuous variable $\mathbf{Y}^*$ has three threshold points. In our case, height-for-age z (HAZ) score was the continuous variable. From this score, a child was considered to suffer from severe undernutrition if his/her HAZ score is below -3. The child is considered to suffer from moderate undernutrition if their HAZ score is between -3 and -2.01. A child will be considered to have a good or acceptable nutrition stock if her/his HAZ score is greater than -2.01.

Hence, in the population, the continuous latent variable Y_i^* is:

$$Y_i^* = \sum_{k=1}^{K} \beta_k X_{ki} + \epsilon_i = Z_i + \epsilon_i \qquad (1)$$

In this case, the disturbance error term (ϵ_i) is random and has a standard logistic distribution with a mean of 0, and a standard deviation of 1: i.e., N(0,1).

4.4.1 Model Specification

The ordered logit has the following form:

$$haz_i^* = x_i'\beta + u_i \begin{cases} haz_i^* = 1 \text{ if } haz_i \leq \text{-300 (severe undernutrition)} \\ haz_i^* = 2 \text{ if -301} \leq haz_i \leq \text{-201 (moderate undernutrition)} \\ haz_i^* = 3 \text{ if } haz_i \geq \text{-200 (no undernutrition)} \end{cases} \qquad (2)$$

where $p_1 + p_2 + p_3 = 1$. These are the respective probabilities of being in different categories. For example, p_1 will be the probability of being in category 1, which in our case is severe undernutrition; p_2 will be the probability of being in category two (moderate undernutrition); and p_3 will be the probability of being in category three (good or acceptable nutrition stock). α_k will be the cut-off point for the respective category. The vector x will be the vector of explanatory variables; and β will be the vector of coefficients.

4.4.2 Pre-estimation Tests
As highlighted above, there was only one pre-estimation test carried out, which is the multicollinearity test. Multicollinearity is a situation where there exists a perfect or exact linear relationship between independent variables in a regression model. The correlation matrix was utilized to check for multicollinearity. The rule of thumb says if the absolute correlation coefficient between any two explanatory variables is 0.8 or above, the variables will be correlated. Multicollinearity poses problems in regression models such that the confidence intervals will be much wider (Balgati, 2013), which may lead to a quick acceptance of the null hypothesis. In addition, multicollinearity affects the t-values associated with the coefficients to be statistically insignificant. Multicollinearity can be solved by dropping one of the highly correlated variables from the model.

4.4.3 Post-estimation Tests
Two post-estimation tests were carried out, and these include model specification test, and parallel regression assumption test.

1. Models Specification Test
A Link test was carried out to see if the models estimated were correctly specified. According to this test, if our model is really specified correctly, then, if we regress the dependent variable on the prediction and the prediction squared, the prediction squared would have no explanatory power; that is, it should have a p-value greater than the acceptable levels of significances (0.1, 0.05 and 0.01).

2. Parallel Regression Assumption Test
The ordered logistic model is also known as the proportional odds model. This is because the odds ratios of all the categories involved are assumed to be proportional. This assumption is also known as the parallel regression assumption. In this study, the Brant test will be used to test whether this assumption holds or not. Under this test, a significant test statistic provides evidence that the parallel regression assumption was violated.

5. Results and Discussion

5.1 Descriptive Statistics

The dependent variable in the model to assess the causes of undernutrition is an ordinal variable with three categories. In this research, the study used stunting only to measure nutrition stock (or nutrition status) since children who are stunted are also likely to suffer wasting and underweight problems (Development Initiatives, 2018). More so, stunting is the biggest problem in the country compared to other ways of measuring malnutrition. The results from the 2015 ZDHS are shown in Table 4.

Table 4 indicates that, at the national level, 8% of the children whose mothers were interviewed are seen to be suffering from severe undernutrition. More so, 18% of the children whose mothers were interviewed have been categorized as suffering from moderate undernutrition.

Table 4: Nutrition Status (Stock) of Children Under-five, Stratified by Residence

Nutrition Status (Stock)	Rural (%)	Urban (%)	National (%)
Severe Undernutrition	0.09	0.07	0.08
Moderate Undernutrition	0.19	0.15	0.18
Good Nutrition	0.72	0.78	0.74

Source: Author's Calculations from the 2015 ZDHS Data

Hence, using the traditional way, the total percentage of children suffering from undernutrition as calculated using the 2015 ZDHS was 26% at the national level. The figure was 28% in rural areas, and 22% in urban areas. These statistics warrant the need to carry out the study given that the figures are above the >20% mark, which is being targeted to be achieved in 2030 by the country and the whole world (MoHCC, 2016; Development Initiatives, 2018). However, 74% of the children whose mothers were interviewed at the national level have been categorized as having good nutrition stock: that is, neither being severely undernourished, nor moderately undernourished. For rural and urban residences, the figures are 72% and 78%, respectively.

In addition to the descriptive statistics of the dependent variable which has been given by Table 4, this section also gives the description of explanatory variables that were motivated by section 4.2. These descriptive statistics are given in Table 5.

Table 5: Descriptive Statistics for Categorical Variables

Categorical Variable	Category	Rural (%)	Urban (%)	National (%)
Religion	Apostolic	64	32	54
	Other	36	68	46
Drinking Water	Improved	11	18	14
	Unimproved	89	82	86
Toilet Facility	Improved	44	95	60
	Unimproved	56	05	40
Cooking Fuel	Clean	05	68	25
	Unclean	95	32	75
Premature Birth	Yes	09	10	09
	No	91	90	91
Birth Interval	Long	69	74	70
	Short	31	26	30
Single Birth	Yes	97	95	96
	No	03	05	04
Child Gender	Male	50	48	49
	Female	50	52	51
Maternal Age	35+ years	07	05	07
	35– years	93	95	93
Maternal BMI	Undernourished	05	02	04
	Normal and Over	95	98	96
Maternal Education	Tertiary	02	13	05
	Secondary or less	98	87	95

Table 5 shows that the religion of the interviewed mothers indicated that in rural areas, 64% were following the religious doctrine of the apostolic faith sect; whilst 34% were following other doctrines. For urban areas, there is indication of 68% of the mothers following other religious doctrines, whilst 32% followed the apostolic sect. This leaves the national statistic being close to being balanced: with 54% following the apostolic sect, and 46% following other religious doctrines.

Moreover, Table 5 shows that there are significant challenges in the access to safe drinking water at the national level; with only 14% of the children having access to improved drinking water facilities, whilst the remainder are using unimproved drinking water sources. However, there are positive results as far as the toilet facilities being used are concerned: 60% of households had access to improved toilet facilities, whilst the remainder had access to unimproved toilet facilities at the national level. However, 95% of urban dwellers had access to improved toilet facilities, whilst the figure was 44% for rural dwellers. Furthermore, Table 5 shows that access to clean energy was a major problem in Zimbabwe, especially in rural areas. Only 25% of the households with children under the age of five had access to clean energy at the national level. The figures were 68% and 5% for urban and rural households, respectively. This makes sense given that the major source of energy in urban areas is electricity, whilst that of rural areas is firewood (ZNSA & ICF International, 2016).

In addition, for the child-specific characteristics, Table 5 shows that only 9% of the children in the survey were born prematurely at the national level. However, the figures for children born prematurely in rural and urban areas were 9% and 10%, respectively. Generally, Table 5 shows that the bulk of children were born maturely. Furthermore, at the national level, 70% of the children were born with a long birth interval between them and the previous siblings. However, when stratified by residence, the figures become 69% and 74% for rural and urban areas, respectively. In addition, 96% of the children were born in singleton (not twins or triplets) at the national level, whilst the same figure was 97% and 95% in rural and urban areas, respectively. When it comes to the gender of the children, 49% of the children were boys, whilst 51% were girls. In the rural areas, the figures were shared equally: i.e., 50% boys, and 50% girls. However, in the urban areas the percentages were 48% for boys and 52% for girls.

In terms of maternal characteristics, only 7% of the children were born with mothers who were older than 35 years; whilst the remainder were born with mothers aged less than 35 years. These were the same figures that were recorded in the rural areas, whilst in the urban areas the figures were 95% for children born to mothers who were less than 35 years old, whilst the remainder were born to mothers older than 35 years. In terms of maternal nutrition, only 4% of the mothers were considered to be undernourished at the national level, whilst the figures were 5% and 2% for rural mothers and urban mothers, respectively. In short, Table 5 shows that more mothers from the rural areas were considered undernourished compared to urban mothers. Furthermore, Table 5 also shows that the majority of the mothers did not achieve tertiary level education; with only 2% of mothers in the rural areas having achieved tertiary level of education. The national statistics for this variable was 5%, whilst that of urban mothers was 13%.

5.2 Factors Causing Undernutrition in Under-five Children in Zimbabwe

An ordered logistic regression was carried out to determine factors affecting the nutrition stock of children under-five years in Zimbabwe. The dependent variable was weight-for-age z-scores, grouped into three groups. These groups were severe undernutrition, moderate undernutrition, and good or acceptable nutrition stock. Due to backward stepwise regression, some variables were dropped from the model. Notable ones include maternal employment and family wealth. The results of the ordered logistic regression are shown in Table 6.

Table 6: Causes of Under-five Undernutrition in Zimbabwe

Dependent Variable	Coefficient	Standard Error	P > |t|	[95% Conf.	Interval]
Birth Interval	-0.23**	0.12	0.05	-0.47	0.01
Child's Sex	-0.40***	0.10	0.00	-0.60	-0.19
Cooking Power	0.79***	0.19	0.00	0.43	1.16
Maternal Age	-0.14	0.18	0.45	-0.49	0.22
Maternal BMI	-0.35	0.26	0.17	-0.86	0.15
Maternal Education	-1.12***	0.33	0.00	-1.77	-0.46
Premature Birth	-0.66***	0.16	0.00	-0.97	-0.34
Religion	-0.18	0.12	0.12	-0.41	0.05
Residence	-0.53***	0.17	0.00	-0.86	-0.20
Safe Drinking Water	0.31**	0.15	0.05	0.01	0.61
Single Birth	0.49*	0.29	0.09	-0.08	1.07
Toilet Facility	0.26*	0.13	0.06	-0.01	0.52

Note: Significance Level: * P<0.1; ** P<0.05; *** P<0.01. Number of observations: 2,812. Population Size: 2,910. Number of strata: 19. Number of PSUs: 397. F (12, 367) = 7.68. Prob > F = 0.00

Source: Author's calculations using the 2015 ZDHS Data

Coefficients estimated from an ordered logistic model only give the direction of change, i.e., if the sign is negative, then a positive change in the explanatory variable will be associated with a reduction of the probability of being in the higher category (in this case good nutrition stock). For example, we can only conclude from Table 5 that a shorter birth interval, being male, maternal education of less than tertiary level, premature birth, and urban residence: all these reduce the probability that a child will have a good nutrition stock since these variables are carrying negative signs. To see the absolute change in probabilities of being in respective categories, marginal effects have been calculated and are going to be used in the interpretation instead of the coefficients. However, model diagnostic tests must be carried out first.

5.2.1 Model Diagnostic Tests

The diagnostic tests carried out for the model estimated above include goodness of fit test, model specification test, and the parallel regression assumption test.

1. Goodness of Fit Test
The classical way of measuring the goodness of fit of any model—i.e., the adjusted R squared—does not work for the ordered logistic model estimated above. The best way to estimate how good is our model as far as the predictive power is concerned is by using the estimated probabilities and comparing those with the frequencies or proportions of being in the respective categories using the raw data. Hence, after the model was estimated, the *mfx predict outcome* command in Stata was used to estimate the probabilities of being in any of the three categories; and they were compared with the proportions from the raw data.

Table 7: Ordered Logistic Model Goodness of Fit

Nutrition Status (Stock)	Raw data Proportion	Predicted Probabilities	Estimated Proportion
Severe Undernutrition	0.08	0.06	0.07
Moderate Undernutrition	0.18	0.17	0.17
Good/Acceptable Nutrition	0.74	0.77	0.76

Source: Author's Calculations using the 2015 ZDHS

From Table 7, there is sufficient evidence to conclude that our model performs well as far as predicting power is concerned, since there are little differences between the predicted probabilities, estimated mean, and the frequencies from the original data set. For example, the raw data proportion of children considered suffering from severe undernutrition in 8%, whilst the fitted model estimated that 7% of the children suffers from severe undernutrition. Marginal effects predict this figure to be 6%. For children suffering from moderate undernutrition, the raw data showed that 18% were suffering from moderate undernutrition, whilst the model estimated that 17% of the children were suffering from moderate undernutrition. Marginal effects predicted this figure to be 17% as well. The model also predicted that 76% of the children had good nutrition stock, whilst the actual proportion from the raw data was 74%. Hence, we may conclude that our model fits well, since there are little differences between the actual proportions from the raw data and the proportions predicted by the model.

2. Model Specification Test
A link test was carried out to see if the fitted model was correctly specified. The results are presented in Table 7. According to this test, a model is correctly specified if the squared estimate (the variable _hatsq in Table 7) is insignificant; that is, if its p-value is greater than the required level of significance.

Table 8: Ordered Logistic Model Specification Test-Link Test.

Nutrition Status	Coefficient	Standard Error	P > |t|
_hat	0.94	0.21	0.00
_hatsq	-0.04	0.11	0.73

Source: Author Calculations using the 2015 ZDHS Data

From Table 8, the coefficient of the squared estimate (_hatsq) has a p-value of 0.73. This is greater than the acceptable level of significances (0.10, 0.05, and 0.01). Hence, we may conclude that _hatsq is insignificant, and the model was correctly specified.

3. Parallel Regression Assumption Test

The ordered logistic model is also known as the proportional odds model. This is because the odds ratios of all the categories involved are assumed to be proportional. This assumption is also known as the parallel regression assumption. With the model fitted using survey data, Stata does not allow this test to be carried out. Trying to run the command for this test (*brant* command) in Stata gives back an error saying the command is not supported for survey set data. However, the model was estimated without the *svy* command, and the results showed that the assumption was not violated. The results are shown in Table A2.

5.2.2 Marginal Effects and Their Interpretation

The results for the marginal effects are presented in Table 9. For an explanatory continuous variable, marginal effects measure the change in the probability of being in respective categories as the explanatory variable changes. For a categorical explanatory variable, marginal effects compare the probability of being in the respective categories of the dependent variable between the categories of the explanatory variable.

Table 9: Ordered Logistic Regression Model Marginal Effects

Dependent Variable	Severe Undernutrition	Moderate Undernutrition	Good/Acceptable Nutrition	P > |t|
Birth Interval	0.01	0.03	-0.04	0.07
Child's Sex	0.02	0.05	-0.07	0.00
Cooking Power	-0.04	-0.09	0.12	0.00
Drinking Water	-0.01	-0.04	0.05	0.03
Maternal Age	0.01	0.02	-0.02	0.47
Maternal BMI	0.02	0.05	-0.07	0.23
Maternal Education	0.04	0.10	-0.15	0.00
Premature Birth	0.05	0.09	-0.13	0.00
Religion	0.01	0.02	-0.03	0.12
Residence	0.03	0.07	-0.10	0.00
Single Birth	-0.03	-0.06	0.10	0.16
Toilet Facility	-0.02	-0.03	0.05	0.06

Source: Author's Calculations using the 2015 ZDHS Data

The space between the children (preceding birth interval) was found to be a factor influencing the nutritional stock of a child. Children who were born with a short birth interval (less than 33 months) were found to be 1% more likely to suffer from severe undernutrition compared to children who were born with the recommended birth interval (33 months or more). They were also found to be 3% more likely to suffer from moderate undernutrition. However, children with a short birth interval were also found to be 4% less likely to be in good or acceptable nutrition status category. In short, a long birth interval improves the nutrition stock of a child, whilst a short birth interval worsens it. This is true at a 1% level of significance. From a theoretical perspective, a bigger gap between children will give sufficient time for breastfeeding, leading to better nutrition for children (Development Initiatives, 2018; FNC, 2018). Other empirical studies also found similar results (Adhikari et al., 2019).

The gender of a child was also found to be a significant determinant of a child's nutritional status. Compared to female children, boys under the age of five were 2% more likely to suffer from severe undernutrition. Boys were also 5% more likely to suffer from moderate undernutrition. Similarly, in comparison with girls of the same age, boys under the age of five years were 7% less likely to have a good nutrition stock. In short, evidence from the 2015 ZDHS showed that boys under the age of five are more likely to suffer undernutrition problems compared to girls of the same age. This was true at a 1% level of significance.

The type of fuel used for cooking food was also found to influence the nutritional status of children. Compared to children whose food was prepared using solid fuel, children whose food was prepared using clean fuel were 4% less likely to suffer from severe undernutrition. They were also 9% less likely to suffer from moderate undernutrition. On the other hand, they were 12% more likely to have good nutritional stock. In short, clean fuels prepare food better compared to solid fuels. This was true at a 1% level of significance.

Safe drinking water was also found to reduce undernutrition problems. Compared to children born to a household without access to safe drinking water, children born to a household with access to safe drinking water were found to be 2% less likely to suffer from severe undernutrition. They were also found to be 4% less likely to suffer from moderate undernutrition. However, being born to a household with access to safe drinking water increased the probability of the child having good or acceptable nutrition stock by 5%. In short, safe drinking water reduces undernutrition problems to children under the age of five in Zimbabwe. Safe drinking water reduces diseases such as cholera, which negatively affect the digestive system, and hence the nutrition of a child. This was found to be true at a 5% level of significance.

Maternal education was found to be one of the factors determining the nutrition stock of the children under-five years old in Zimbabwe. Being born to a mother who achieved only a secondary level education or less increased the probability that a child will suffer from severe undernutrition by 4%. This also increased the probability that a child will suffer from moderate undernutrition by 10%. However, being born to a mother who achieved a secondary level education or less reduced the probability that a child will have a good nutrition stock by 15%. In short, the research found that as a mother achieves tertiary education, the problems of undernutrition will be reduced, and a child born to this mother will likely have a good nutrition stock. Also, a well-educated mother is likely to earn more on the labour market, which will in turn increase expenditure on child health, thereby improving a child's health. More so, as advocated by Becker (1993), an educated mother is likely to have better childcare methods compared to a non-educated mother (Becker, 1993).

Moreover, children who were delivered prematurely were also found to have more undernutrition problems compared to children born maturely. Compared to children who were born maturely, children of premature births were found to be 5% more likely to suffer from severe undernutrition. They were also found to be 9% more likely to suffer from moderate undernutrition. However, compared to children who were born maturely, children who were born prematurely were 13% less likely to have an acceptable or good nutrition stock. This assertion is true at a 1% level of significance. This was also predicted by the UNCEF Framework on Child Nutrition and Mortality (UNICEF, 2015; UNIGME, 2017). Empirically, these are consistent with results found in other jurisdictions such as Nepal (Adhikari et al., 2019), Bangladesh (Talukder, 2017) and Sierra Leone (Sondai et al., 2017).

Improvement in the toilet facility of a household was also found to reduce undernutrition problems in children under the age of five in Zimbabwe. Again, the WHO and other UN agencies advocate better sanitation methods to improve the overall health of the population. These sanitation methods include using improved toilet facilities (MoHCC, 2015). With that in vein, this study found that compared to children who live in a household that uses unimproved toilet facility, children born to a household that uses improved toilet facility were found to be 2% less likely to suffer from severe undernutrition. They were also found to be 3% less likely to suffer from moderate undernutrition. Also, a child born to a family that uses an improved toilet facility is 5% more likely to have good or acceptable nutrition stock. This was found to be true at a 10% level of significance. In comparison, a meta-analysis by Charmarbagwala et al. (2012) also found similar results.

For the period from 2010 to 2015, children who resided in rural areas were found to have more undernutrition problems compared to their urban counterparts. This may be due to the fact that the level of household income in Zimbabwe is better in urban areas as compared to rural areas. More so, most functioning healthcare centres in the country are in urban areas when compared with rural areas (MoHCC, 2015). All these factors can contribute to children residing in urban areas being healthier compared to children living in rural areas. In this study, children living in rural areas were found to be 3% more likely to suffer from severe undernutrition. They were also found to be 7% more likely to suffer from moderate undernutrition. However, children living in rural areas were found to be 10% less likely to have a good nutrition stock compared to children living in urban areas. These statements were true at a 1% level of significance.

6. Conclusion and Recommendations

This study explored the relationship between child nutrition status and other socioeconomic variables using data from the latest ZDHS, which was the 2015 ZDHS. The relationship was explored using an ordered logistic regression econometric model. The study results indicated that sanitation and hygiene, maternal education, the gender of the child, and mature birth are the factors that affect the nutritional status of children under the age of five in Zimbabwe. With these results, the study give the following policy recommendations;

- Subsidising education, especially for the girl child, will go a long way in improving the health of children under the age of five in Zimbabwe. There is a need to continue convincing women who fell pregnant during their education to continue with education as time permits. This can be communicated directly with community leaders and schools, especially in the rural arears, where people still believe that once a girl gets pregnant, she ought to drop out of school.
- There is a need to improve sources of safe drinking water, and toilets facilities used by the majority of citizens in the country.
- Campaigns should be made to encourage women to use birth control measures so as to increase the time between the siblings.
- The government should make efforts to reduce the chances of premature births since children born prematurely will have a difficult start to life, leading to poor health in their first five years.

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Appendices

Table A1: Multicollinearity Test

```
. correlate educ01 bmi01 mage2 religion3 childsex res hv237 alcohol birthint premature single power sanitation visi
> ts h_insurance
(obs=2,717)
```

	educ01	bmi01	mage2	religi~3	childsex	res	hv237	alcohol	birthint	premat~e	single
educ01	1.0000										
bmi01	0.0292	1.0000									
mage2	0.0077	0.0149	1.0000								
religion3	0.2119	0.0159	-0.0165	1.0000							
childsex	0.0025	-0.0184	-0.0026	0.0309	1.0000						
res	-0.2173	-0.0761	-0.0324	-0.2864	-0.0321	1.0000					
hv237	-0.0733	0.0106	-0.0175	-0.0136	-0.0029	0.0139	1.0000				
alcohol	-0.0793	-0.0315	-0.0326	-0.1235	0.0404	0.1384	0.0007	1.0000			
birthint	0.0085	0.0211	-0.0773	0.0457	-0.0198	0.0140	0.0197	0.0215	1.0000		
premature	0.0078	0.0207	0.0073	-0.0149	-0.0473	0.0429	0.0280	0.0069	-0.0185	1.0000	
single	-0.0026	0.0163	-0.0069	0.0202	0.0236	-0.0153	-0.0169	0.0180	0.0024	-0.2224	1.0000
power	-0.2823	-0.0714	-0.0316	-0.2860	-0.0532	0.6561	0.0367	0.1379	-0.0062	0.0303	-0.0146
sanitation	-0.1780	-0.0326	0.0048	-0.1860	-0.0065	0.4813	0.0677	0.0867	-0.0427	-0.0170	0.0031
visits	-0.1693	-0.0180	0.0361	-0.1109	0.0127	0.0575	0.0586	0.0285	-0.0945	-0.0036	0.0190
h_insurance	-0.4639	-0.0447	0.0120	-0.2361	-0.0125	0.2926	0.0637	0.0925	-0.0438	-0.0116	-0.0225

	power	sanita~n	visits	h_insu~e
power	1.0000			
sanitation	0.4253	1.0000		
visits	0.1161	0.0797	1.0000	
h_insurance	0.3886	0.2124	0.1856	1.0000

Table A2: Parallel Regression Assumption Test

```
. brant

Brant test of parallel regression assumption
```

	chi2	p>chi2	df
All	11.86	0.457	12
educ01	0.45	0.504	1
bmi01	0.42	0.519	1
mage2	0.63	0.429	1
religion3	0.56	0.454	1
single	1.31	0.253	1
childsex	0.19	0.661	1
res	0.05	0.820	1
hv237	2.13	0.144	1
birthint	1.60	0.206	1
premature	0.32	0.569	1
power	1.70	0.192	1
sanitation	0.05	0.817	1

```
A significant test statistic provides evidence that the parallel
regression assumption has been violated.
```