An investigation of the determinants of childhood stunting in Zambia

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DECLARATION

I Kekelwa Munalula declare that this research report entitled 'An investigation of the determinants of childhood stunting in Zambia' is my own unaided work. I have acknowledged, attributed, and referenced all ideas sourced elsewhere. I am hereby submitting it in partial fulfilment of the requirements of the degree of Master of Management (Development and Economics) in the University of the Witwatersrand, Johannesburg. I have not submitted this report before for any other degree or examination to any other institution.

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ABSTRACT

Background

Stunting in Zambia is a prevalent public health concern that can be attributed to multiple factors. Understanding the risk factors for stunting in children under the age of five is critical for developing nutritional intervention programs and strategies. As a result, this study aimed to analyze the marginal effects of the underlying determinants of child nutrition on Child stunting levels in Zambia.

Method

This study employed secondary data sources from Zambian demography and health surveys from six surveys. Relevant data were extracted from Kids Record (KR) and the corresponding Household Record (PR) file for the final analysis; survey rounds between 1992 up to 2018 were included in the study. Binary logistic regression model was used to describe the determinants and their association with childhood stunting. Further Marginal analysis was used to establish the marginal effects associated with the determinants.

Result

Children living in low social economic conditions, children who reside in urban areas, have healthcare access challenges, born in non-medical facility, and whose mothers had lower than secondary education were more likely to be stunted. Further, narrow birth intervals, and low birthweight were associated with an increased occurrence of stunting.

Conclusion

Stunting is the outcome of an intricate interaction of determinants. Wealth index, maternal education, maternal nutrition, birthweight, place of birth, birth interval and source of drinking water were found to have the highest marginal effects on childhood stunting. Therefore, policy makers should consider these determinants in the design of nutrition intervention programs.

KEY WORDS; Stunting, determinants, child, Zambia

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INTRODUCTION TO THE RESEARCH

Malnutrition defined by Harris (2019) as the condition of not having adequate daily food to provide energy to lead an active and productive life, is a major global health concern. Child malnutrition generally takes three forms: undernutrition, overnutrition and nutrient deficiencies. Undernutrition is mainly caused by insufficient food intake and illness, and later manifests as stunting, underweight, or wasting (Black et al, 2013). In contrast, excessive consumption of unhealthy food and a lack of physical activity leads to overnutrition, which manifests as overweight and obesity (Bhadoria, 2015). Additionally, nutrient deficits including those caused by iron and vitamin A deficiency arise from inadequate intake of critical micronutrients (Grebmer et al, 2014).

Malnutrition in all its forms negatively effects the development and growth of children. In the initial years after birth, a child's brain and physiology expand the fastest, making this time critical for cognitive and motor development. According to several research studies, malnourished children prioritize their energy by allocating minimal calories to their intellectual, emotional, and physical development, which reduces their ability to absorb information and learn (Black et al, 2013). Numerous other studies have emphasized the detrimental effects of undernutrition on a child's intellectual growth (Nyaradi et al, 2013; Gratham et al, 2007; Casale et al, 2016). Children affected by malnutrition are more likely to skip class, repeat grades, or quit school (Hoddinot, 2008; Walker, 2015; Perignon, 2014).

Malnutrition impacts about 1 billion people worldwide, with 150 million children stunted. Malnutrition is at the root of many social and economic implications in the short and long term (Development Initiatives, 2018; Harris, 2019, McGovern et al., 2017). The incidence of malnutrition is highest in Southern Africa where it is responsible for 45% of fatalities in infants (WHO, 2021). Recent statistics show that there have been notable declines in the global prevalence of malnutrition in the past two decades but the levels remain unacceptably high in Zambia where 4 out of 10 children are estimated to be stunted (Harris 2017).

The causes of child malnutrition are multifaceted, intricate, and frequently interconnected (Habtu et al., 2022; Bhuta et al., 2013). They are primarily divided into three categories: direct determinants (poor diet and disease), underlying determinants (food, health, and care), and basic determinants (associated with political, economic, social, and ethnic factors) (Black et al., 2013; UNICEF, 1990; UNICEF 2020)

In recent years, there has been a rise in academics' interest in the role of policy integration in dealing with issues such as malnutrition (Candel, 2021; Candel & Biesbroek, 2016a, 2016b; Nordbeck & Steurer, 2016; Peters, 2013; Casado-Asensio & Steurer, 2014). This prominent ideology has been based on illustrations that show that malnutrition has multi-dimensional causes and effects which span across established authorities, governance levels, and policy areas and therefore requires a holistic integrated approach to combat (Coile et al., 2021; Garrett & Natalicchio, 2011). According to Dewey and Begum (2011) and de Onis (2016) malnutrition is connected to ill health and poor productivity outcomes in later life. The term malnutrition encompasses a wide range of nutrient deficiencies with undernutrition and child stunting being the most recognized form of malnutrition in Zambia (Harris, 2019).

Owing to its scale of impact and well-established hypothesized factors, there is a global and national urgency to eradicate undernutrition. It has been suggested that integrated or blended nutrition approaches that are more comprehensive and cross-sectoral which are aimed at the integration of the different sectors for a common goal are likely to be more effective in combating malnutrition (Habtu et al., 2022; Ruel et al., 2013; Nordbeck & Steurer, 2016).

This view provides a sharp contrast from the health perspective common before the 1990s that presumed that infection or poor diet led to malnutrition. The insufficiencies of the earlier model are further made obvious by the awareness of the complex causality of malnutrition, which highlights how nutrition is intricately tied to circumstances across many sectors, including agriculture, education, and community development. Therefore, malnutrition requires not only dealing with direct causes but the underlying factors also need to be addressed (Ruel, 2013).

The Lancet (2013) series on nutrition proposed that the underlying and direct factors of nutrition identified in a particular context, must be the basis upon which nutrition interventions should be designed (Ruel et al., 2013; Bhutta et al., 2013). As a result, integrated nutrition strategies typically recommend combining nutrition specific interventions (targeting direct factors) with nutrition sensitive programs (targeting underlying factors) (Shenut et al., 2020). Nutrition-specific interventions include the supplementation of micronutrient for both mother and child, breastfeeding promotion, and hygienic practices while nutrition sensitive programs and initiatives make use of related sectors such as child protection, food and agriculture, to target the underlying factors (Pelletier et al., 2017; Ruel, 2013). The Lancet series further emphasizes that, if implemented on a wide scale, nutrition-specific treatments on their own can only reduce malnutrition by 20%, whereas nutrition-sensitive programs would take care of the remaining 80% (Bhutta et al., 2013).

Against this background, the need to better understand malnutrition causality and improve intervention targeting is evident. According to Garret et al. (2011), recommendations for action against malnutrition must adapt to specific situations. This emphasizes the need to understand determinants of nutrition in different contexts in order to design appropriate interventions.

In line with these recommendations, the Zambian government and international donors are focused on the delivery of integrated interventions to address malnutrition through cross-sectoral policy integration amongst sectors. Based on some studies conducted, stunting levels showed a reduction between 2001 and 2018 from 46% to 35% (Zambia Statistical Agency, 2018). Notably, these declines are far below the goals needed to put an end to childhood malnutrition in the current generation. According to estimates, the nation's progress toward the goal of reducing the rates of stunting by half (in line with World Health Assembly targets) is unlikely to be attained (Black et al., 2013).

The focus of the Zambian nutrition community has since shifted to current stunting narratives and integrated nutrition interventions (Harris et al., 2017; Haggblade et al., 2015). Currently, Zambia's main nutrition priority includes the continuous rollout of integrated nutrition programs throughout the country.

1.1 The research problem statement

Zambia's malnutrition rates are exceedingly high, and among the highest in the world, with a stunting rate of 35%, which is notably higher than the Sub-Saharan Africa average of 23% (Harris, 2019). The Zambian government has since 2011 adopted integrated approaches to tackle malnutrition by designing and implementing initiatives which combine nutrition specific and nutrition sensitive programs. However, policy makers find it challenging to design effective integrated nutrition programs. Notably there are challenges arising from the lack of knowledge regarding which determinants of nutrition have the highest impact on undernutrition (Gaihre et al., 2019). On the other hand, there is a growing recognition of the need to have an understanding of the effectiveness of integrated approaches to tackling undernutrition and the role of different factors in driving changes in nutrition (Gaihre et al., 2019). Despite the increasing attention to nutrition, little attention has been given to generating evidence on the contribution of different factors to child malnutrition. There have been several studies on plausible drivers of nutritional change in Zambia (Headey et al., 2015; Moonga, 2001; kandala, 2010) and on the development of integrated nutrition efforts (Garrett & Natalicchio, 2011; Harris, 2019). However, very few studies have been done to assess the roles of underlying determinants in the manifested high rates of stunting levels in Zambia. Therefore, it remains unknown which particular determinants to prioritize during intervention design, resulting in the application of uniform nutrition intervention packages in different contexts. Further, most studies on factors of nutrition in Zambia have been based on data that is dated. Smith and Haddad (2015) rightly point out that the combination of specific variables that have driven changes in nutrition outcomes do not remain constant over time and some may in fact become insignificant in the future for various reasons.

1.2 Main Research Question

To what extent do the underlying determinants food security, care practices and health environments influence the occurrence of stunting among children under 5 years old in a Zambia?

1.2.1 Specific Research questions

1. What are the changes in stunting levels in the last 30 years?
2. Which underlying determinants have driven the changes in childhood stunting in the past 30 years and what have been the changes to these determinants?
3. What are the estimated marginal effects of the determinants on childhood stunting?

1.3 Research Purpose and Objectives

1.3.1 Research Purpose

The purpose of this study is to analyze the marginal effects of the underlying determinants of nutrition on childhood stunting levels in Zambia.

1.3.2 Research Objectives

1. To capture the changes in child stunting in the last 30 years.
2. To identify and measure trends in underlying determinants in the past 30 years.
3. To estimate the marginal effects of these identified determinants on childhood stunting in Zambia.

1.4 Delimitations of the research

While it has been established that different form of malnutrition exist, such as wasting, stunting, and underweight, this study focuses on childhood stunting for children under the age of 5.

1.5 Preface to the research report

To this end, the report comprises six chapters. Following this introductory chapter, Chapter 2 provides a review of the literature that discusses the problem, earlier studies related to the research, and the conceptual framework. Chapter 3 discusses the research strategy, design, procedures, reliability and validity measures as well as limitations. Chapter 4 and Chapter 5 present and discuss the findings, respectively, from investigating the research questions while Chapter 6 summarises and concludes the research.

2 LITERATURE REVIEW

Malnutrition is a major development issue worldwide. According to Haddad (2014), malnutrition undermines economic growth and perpetuates poverty while contributing to the widespread failure to meet other development goals. Specifically, it has been connected to cognitive function, academic success, adult productive capacity, and a rise in non-communicable diseases. (Groot et al., 2017; Adair et al., 2013; McGovern et al., 2017; Dewey & Begum, 2011).

Conversely, while economic growth has been known to have significant effects on the prevalence of undernourishment (Nisbett et al., 2014; Collier, 2007; FAO, 2012), Vollmer et al (2014) present a different stance on this relationship. Vollmer et al. (2014) assert that economic growth makes minimal contributions to changes in undernutrition in developing nations. The persistence of malnutrition despite economic growth, and interconnectedness to practically every facet of poverty and development, has resulted in a renewed global political momentum to combat malnutrition and increased government spending on nutrition (Ruel & Alderman, 2013; Nisbett et al., 2014).

Malnutrition in Zambia manifests as stunted growth and is considered to be outside the bounds of what is outlined as acceptable; at 35%, this affects nearly one in every two of its children (Statistics Agency Zambia, 2020; Harris et al., 2017). Statistics from the Zambia Demographic and Health Survey [ZDHS] (2018) indicate that rates of stunting for children below the age of 5 decreased considerably between 1992 and 2018, dropping from 46% to 35%. This decrease in child stunting was driven by multiple factors, including improved healthcare and advancements in water and sanitation (Harris et al., 2017a). According to the ZDHS (2018), the incidence of stunting increased from 19% among younger infants to 46% among infants aged 18 to 23 months, highlighting the significance of a healthy diet for young children.

Zambia has an economy that depends on agriculture and natural resources and graduated to middle-income country status in the year 2011 (OECD, 2019). Despite Zambia's comparatively high GNI per capita of $3464, available data indicates that poverty and social vulnerability still pose a problem. In actuality, Zambia's economy continues to be characterized by low-income and has high levels of poverty. Fifty four percent (54%) of Zambians live in poverty, which is higher in rural regions (77%) than in urban regions (23%) (CSO, 2016).

2.1 History and development of nutrition policy in Zambia

Zambia has come a long way in addressing issues concerned with nutrition. As outlined by Harris et al. (2017) and Harris (2017), several key events have acted as precursors to the formulation of policies and strategy related to nutrition. The establishment under Ministry of Health of the

National Food and Nutrition Commission (NFNC) in 1967 was followed by national programs to deliver specific micronutrients (Harris et al., 2017). These programs are still in existence today in some capacity (Haggblade et al., 2016; Harris, 2017). In addition, the completion of the Food and Nutrition Policy (NFNP) in 2006 led to an improvement in the earlier policies on breastfeeding and micronutrients. On the other hand, agricultural policies have historically, incorporated nutrition into its mandate and has placed emphasis on food security to tackle hunger.

Zambia's nutrition agenda has received unprecedented political attention and exceptional momentum recently. Two Lancet publications on nutrition in 2008 and 2013 and the consensus on Malnutrition and hunger by the Copenhagen were contributors to this momentum, with the former serving as an instrument for the Zambian nutrition community's education and activism (Harris, 2017; Gillespie & Bold, 2017; Gillespie, 2014; Hoddinot et al., 2012). Other significant events include creation of strategic plans to address various facets of nutrition 2011-2015; the 2013 Nutrition summit, which attracted USD23 billion for action against undernutrition; three Global Nutrition publications; a Nutrition goals for 2025 by the World Health Organization (WHO) assembly and another goal contained in the Sustainable Development Goals to eliminate all types of malnutrition by 2030 (Gillespie et al., 2021; IFPRI 2016). Lastly, the adoption of integrated nutrition programs like the Scaling Up Nutrition (SUN) have also been significant events in promoting nutrition action through integrated action to include community development, health, agriculture, education, water and sanitation sectors and the focus on stunting (Harris, 2017).

The body of knowledge regarding the determinants of nutrition and nutrition policy has grown over the last few years. However, only recently, has research on nutrition policies been based on empirical studies and established policy science (Nisbert et al, 2014; Gillespie et al., 2013; Harris et al., 2017; Thow et al., 2018). Additionally, most of the early research focused on issues affecting the basic determinants including the political aspects such as agenda setting, and an enabling environment (e.g. Shiffman & Smith, 2007; Shiffman, 2010; Sumner et al., 2011, Resnick et al., 2015; Pelletier et al., 2011 and Sprat, 2013).

The last ten years have seen a lot of effort put into identifying appropriate nutrition-focused programs that are sensitive to nutrition to deal with the direct and underlying factors of malnutrition. Within this time, a subset of the most effective interventions related to the nutrition-specific aspect have been identified. They include the care of acute malnutrition, supplementation of children's diet, maternal micronutrient and folic acid supplementation, and encouragement of breastfeeding (Black et al., 2013). When it comes to nutrition-specific interventions, recent efforts have identified plausible determinants that can be targeted through programs such as those in education, early childhood development, safety nets, and agriculture (Black et al., 2013). Recent studies, however, indicate that additional research into the root causes of child malnutrition is required (Moonga et al., 2021).

2.2 Past studies on the determinants of malnutrition

The analysis of child malnutrition commonly relies on noninvasive measures for stunting, underweight and wasting, indicating inadequate height, inadequate weight for a child's age and inadequate weight-for-height respectively (Kandala et al., 2011). Non-invasive quantitative measurements of the body are mainly used in children to examine their general health condition, and pattern of growth (Casadei & Kiel, 2021).

The perspectives on the mechanisms through which undernutrition develops are well documented. The UNICEF (1990) conceptual framework (modified for LANCET (2013) series on malnutrition, remains the primary tool for understanding the determinants of nutrition and potential solutions for each level of undernutrition. The framework sets out three levels of factors; direct, underlying, and basic determinants.

The literature identifies a number of basic determinants of stunted growth such as religion, ethnicity, economic growth, governance, political freedom, climate change, regional variations, wealth index, parental education and womens' empowerment.

Few studies have looked at the link between religious beliefs and childhood stunting. Even though there have only been a few studies on the subject, religion appears to have substantial influence on stunting in some countries. A study in Nigeria found that religion remained a strong determinant of nutritional status during childhood (OR 0.74 and 0.88) (Atsu et al., 2017; Tesfaw & Fenta, 2021). Despite studies identifying religion as a determinant of stunting, evidence was conflicting on which religion carries a higher risk (Bemnet et al., 2012; Desalegn et al., 2019; Gebru et al., 2019; Tadele Wuneh, 2018). For instance, a study conducted in Ethiopia found that children from Muslim families were at higher risk of stunted growth in comparison to other religions. A study in Ghana compared Muslim, Christian and traditionalists and discovered that households with an atheist (non-religious) head were twice as likely to have children with stunted growth. (OR = 2.024; 95% CI, 1.016–4.034) (Ukwuani & Suchindran, 2003). Similarly, multivariate analyses in Mozambique show that the odds of stunting were lower in children of religiously affiliated women than children of non-religious women (Agadjanian & Jansen, 2017). However, some studies found no association between religion and children's health. For instance, Karlsson, (2019) found no distinctions between Muslims and Christians in terms of child health outcomes in populations with various religious affiliations.

Generally, studies did not find a direct relationship between stunting and Ethnicity. However, a study investigating the diet habits of three ethnic groups in Kenya (Maasai, Kamba and Luo) observed that compared to the Luo, the Kamba and the Maasai were more susceptible to food insecurity which in turn lends them to a higher risk of stunting (Hansen, 2011).

The impact of economic growth on decreasing malnutrition in children is still a widely contested with significant ramifications for food security policies. The literature is highly contradictory, especially when it comes to the size of the affects (on whether economic growth significantly contributes to reductions in child stunting (e.g., O'Connell & Smith 2016; Vollmer et al. 2014; Harjen, 2013, 2012; Ruel et al. 2013; Mary, 2018). While a study by Kachoria et al. (2022) suggests that nutritional status and economic development are positively associated, Vollmer et al. (2014), Joe (2016), and Hartjen (2012) find a quantitatively insignificant association between early childhood undernutrition and increases in per-head GDP. These findings call into question the notion that economic growth improves childhood nutrition but confirm that reducing child stunting involves more than just growth in GDP but also necessitates targeted nutrition interventions. This conclusion appears to represent a point of convergence in the literature (Mary, 2018; McGovern et al. 2017).

While Woodruff (2017) suggests that good governance and childhood stunting are positively linked, Smith and Haddad (2015) found no effect on childhood stunting in the short term. On other hand, political freedom was found to be positively related to the prevalence of malnutrition (Dabir-Alai, 2022).

Several studies have detected geographical differences in stunting and discovered that some places were susceptible to stunting, while others were associated with low incidences (Haile et al. 2016; Duru et al., 2015; Moonga, 2021; Uwiringiyimana et al., 2019; Kinyoki et al., 2016). Yadav et al. (2015) revealed that the prevalence of child malnutrition varied substantially not just among nations but also in different locations of a nation (Menon et al., 2018). Other studies conducted in Zambia investigated regional and spatial differences of stunting and found a significant association (Moonga, 2021; Seboka et al., 2022; Seiler et al., 2021). Additionally, literature has convincingly shown that residence in rural regions carries a higher risk of stunted growth with reference to urban areas (Kismul et al., 2017; Akombi et al., 2017; Darteh et al., 2014). In contrast, an earlier study conducted in Ethiopia observed that children living in rural regions were protected (White, 2012). Further, Aguayo et al. (2016) finds that the place of residence was not a strong predictor of stunted growth and the distinctions in the levels of stunting between urban and rural children was also found to be minimal. Kismul et al. (2017) found significant results in bivariate analysis but place of residence lost its significance in multivariate analysis. Generally, the evidence on geographical differences in stunting remains mixed, with varying outcomes and conclusions across different studies

Some of the fluctuation in child stunting is predicted by climate change, specifically rainfall, droughts, and temperature changes (Cooper et al., 2019; Shively, 2017; Rodriguez-Llanes et al., 2011). A study by Akresh et al., (2022) found that only female children were impacted by crop failure due to climate change, while the study by Rodriguez-Llanes et al. (2011) highlighted that children < 2 years old were more vulnerable to stunting due to climate change.

Wealth indices were significantly associated with childhood stunting in many cross-sectional studies. Most studies used a wealth index as a wealth indicator (Chowdhury, 2020, 2022; Kamal, 2011Kanjilal et al., 2010; Agee, 2010); while others used an asset index (Menon et al., 2018; Islam, 2018). The wealth index is commonly segmented into quintiles, dividing the surveyed population into five equal groups. Each quintile represents a distinct socio-economic category: the lowest, second, third, fourth, and fifth quintiles correspond to the 20% of the population considered the poorest, second-poorest, middle-income, wealthy, and wealthiest, respectively (Rutstein & Johnson, 2004).

Several studies have addressed the relationship between household wealth and stunting in children. Chowdhury (2022) and Kanbar (2012) found that children from the poorest homes have a higher likelihood of stunting compared to those from higher wealth index households. Additionally, a recent analysis by Torlesse et al. (2016) revealed that children living in the lowest socioeconomic bracket faced double the risk of exhibiting stunted growth compared to their counterparts in the highest bracket. Multiple studies consistently demonstrate a negative association between household wealth and stunting, with increased wealth being positively correlated with Height-for-Age Z-scores (HAZ). For example, Ramli et al. (2009) reported that households with unemployed heads were associated with higher probabilities of severely stunted children (OR 2.04). Furthermore, Coretta et al. (2018) observed significantly high rates of stunting across all wealth categories in Zambia, with the lowest wealth category exhibiting rates 1.6 times higher than the highest wealth index. Despite these findings, significant socioeconomic disparities persist, and there is evidence of increasing inequality over time (Coretta et al., 2018).

Quantifying women's empowerment was challenging in most studies. Women's empowerment refers to is the capability of women to make their own decisions and actively engage in all facets of society (Kabeer, 1999). According to Besneir (2016) the relationship between the empowerment of women and the health of children tends to be complex. Studies that investigated this determinant proposed that the effect of indices such as female headed homes (Kang, 2017; Suri, 2014), women's autonomy (Bancha, 2017), and mothers' employment (Gebre, 2019), gender equality (Smith & Haddad, 2015) had conflicting or no association with stunting outcomes. Using a gender life expectancy ratio (women-to-men) as a proxy for empowerment of women, Smith and Haddad (2015) found that the association between women's empowerment and stunting is nonlinear, with lower levels of empowerment having a larger (inverse) effect than higher levels. This result was also found in an earlier study (Smith et al, 2003). This may be explained by the low rates of breastfeeding among women with more authority to make decisions (Smith et al., 2003; Smith & Haddad). Further, Besneir (2016) found that the impacts of women's political empowerment are more significant in middle-income nations. Cross-sectional analyses by Heckert et al. (2019) found that advancements in child nutrition status were a result of advances in the empowerment of women in the areas of marital communication, healthcare and contraceptive choices, and purchasing decisions. Moreover, women's empowerment affects childhood nutrition through its ability to link the adoption of optimal childcare practices to availability of physical and human resources (Heckert et al., 2019; Shroff et al., 2011).

Parental education has been reported to have a reverse relationship with stunting in the vast majority of studies. Numerous studies revealed a strong relationship between caregiver education and childhood stunting. Other studies discovered stunting was linked to maternal education without mentioning or accounting for paternal education (Britto, 2016; Fernald et al., 2012; Oddo et al., 2012; Megabiaw, 2013). While some studies indicated a relationship between parental education and stunted growth without considering which relationship was more significant (Khatun, 2020; Sari et al., 2010). Further, studies discovered paternal education was related to stunting but a larger relationship was observed between stunted growth and mother's education (Chowdhury et al., 2022; Headey et al., 2017; Rachmi et al., 2016b). Research conducted in Kenya observed that higher levels of maternal academic achievement were linked to decreased rates of stunting (Abuya, 2012). In contrast studies undertaken in Ghana and Ethiopia found no association (Suri, 2014; Gebre, 2019; Kismul et al., 2017). A study in Mozambique found that protective effects of education were only found for higher than secondary education with no significant impacts for primary level education attainment (García et al., 2017).

In Zambia, a high literacy rate has been found to be associated with a low stunting levels. In general, the odds of child stunting were reported to be two times higher for children whose parents had the lowest levels of education in comparison to those whose parents had higher levels (Hoffman et al., 2017; Chowdhury et al., 2022). Chowdhury et al. (2022) illustrated that one parent with primary education and the other having secondary education or higher had significantly low likelihood of stunted children in comparison to parents with no education (Chowdhury et al., 2022).

Among the underlying determinants of child undernutrition, research reveals that vaccination, place of birth, prenatal care, postnatal care, the use of micronutrient supplements, access to medical services, home environment, food security and feeding patterns are the main determinants. A number of studies found that immunisations protected children from stunting (Dan, 2020; Rodriguez-Llanes et al., 2011), though some found no association (Demewoz et al., 2016; Gemechu, 2000; Genebo et al., 1999; Shine et al., 2017; Suri et al., 2014; Workineh & Yesuf, 2015). Healthcare services such as skilled birth (Dessie, 2018; Wong et al., 2017; Vaivada et al., 2020; Buisman et al., 2019; Li et al., 2020), antenatal care (Vaivada et al., 2020; Buisman et al., 2019; Kuhnt & Vollmer, 2017; Woodruff et al., 2018; Habima & Biracyaza, 2014), and postnatal care (Kandpal et al., 2016; Tasic et al., 2020; Katoch, 2021) were observed to be inversely related to stunting, though some studies found no association (Buisman, 2019; White, 2019). Supplementation with micronutrients has been shown to reduce the risk of stunting, though disparity in findings exist (Correia et al., 2019; Ssentongo et al., 2020). Further a study conducted in Bangladesh, India, and Peru found no impact on stunting (Goudet et al., 2019). Studies that examined distance or time to a medical facility generally reported that stunting risk was reduced in children whose households were less than five kilometres from a medical facility (Shahid et al., 2022; Semali et al., 2015).

Research that looked into improvements in water and sanitation generally employed indices such as water source, sanitation, distance to places where water is fetched, open defecation. The studies typically found these indicators to be negatively related to stunting (Larsen et al., 2017; Fink, 2011, Spears et al., 2013; Rag et al., 2015; Ilma et al., 2020) although some found conflicting results (Headey et al., 2016; Kismul et al., 2017; Cuesta and Maratou-Kolias, 2017). Rah et al. (2015) and Headey and Palloni (2019) found no association between stunting and water sources. Most studies found it difficult to measure hygiene and was it was not associated with stunting outcomes (Rah et al., 2015). However, the negative relationship between stunted growth and reported hygiene was significant among households with improved water source or sanitation (Fregonese et al., 2017).

Household size was investigated in many studies. Some studies found that smaller household sizes corresponded with reduced stunting levels (García et al., 2017; Greene & Merrick, 2017). Most research that examined the count of children living in a household discovered that the risk of stunting increases as the count of children in the household increases. Further, Darteh et al., (2014) found that stunted growth was more common in homes with higher than 4 children. Children born later than third in the family had 0.379 units lower height for age scores than those born first, indicating that birth order is important in determining stunted growth (Saxton, et al., 2016).

Different breastfeeding practices were examined for their association with child nutritional status and evidence is mixed, though several studies noted positive effects. Darteh et al. (2014) discovered that early commencement of breastfeeding was associated with reduced stunting while Annim (2012) found that while significant, stunting worsened with an increase in breastfeeding duration. These findings are mirrored by Rachmi et al.(2016a) and Rachmi et al. (2016b). These studies revealed that breastfeeding duration of less than half a year was linked to a greater probability of stunting among children (OR 3.16, and OR 2.98, 95% confidence interval). In the same vain, prolonged breastfeeding was linked to higher odds of childhood stunting (Rachmi et al., 2016a, 2016b). Further, Complementary feeding was reported to be significantly linked to childhood stunting in almost all research that examined its association to stunting (Kismul et al., 2017; Fosu-Brefo & Arthur, 2015).

The impacts of food security on children's nutrition status were examined in several studies with results indicating significant influence on stunting (M'Kaibi et al., 2016; Wigle et al., 2020); while others found no significant relationship (Shinsugi et al., 2015).

Diet, diseases, maternal characteristics (body mass index, height, and age), and children's characteristics (birth weight, sex, age, household size and birth order) were identified by literature as the immediate determinants of stunted growth in children. Studies highlighted the importance of enhanced diet, diversification of diet, and supplementation, especially for infants (Nachvak et al., 2020). Research has been done to examine the connection between disease and stunting. Those that examined the impact of anemia found a minimal relationship between stunting risk and the severity of anemia (Larsen et al., 2017). Likewise, diarrhea was also observed to increase the probability of stunting (Paudel et al., 2013; Nabilah et al., 2020), as was Malaria (Headey, 2017). Other research could not link childhood stunting to disease (Kismul et al., 2017; Larsen et al., 2017).

In general, maternal age was not linked to the risk of stunting (Bacha, 2017), but short women (Weatherspoon et al., 2019; Amaha and Woldeamanuel, 2021; Dan, 2020) or those with lower BMI were considerable more likely to have children that were stunted (Chirande, 2015; Haque, 2022) while narrow inter-pregnancy interval and high fertility (high number of children ever born) have been linked with higher stunting probabilities (Tamirat et al., 2021; Dessie,2019). Further children whose mothers had height >150cm had lower stunting probability (Beal et al., 2018).

Regarding children's characteristics, the literature emphasizes that an increase in age increases likelihood of stunting. Recent research has shown that stunting risk was greater in children in the age category 1-2 years old than in children who are less than a year old (Hafid & Nasrul, 2017). Additionally, the chances stunted are higher in under-5 boys compared to under -5 girls (Weatherspoon et al., 2019; Chowdhury et al., 2022). Generally, low birth weight corresponded with higher rates of stunted children (Dessie, 2019).

Other studies have focused on the interactions among the levels of causation. For instance, Smith and Haddad (2015) examine the interaction of the underlying and basic factors of stunting in various countries using econometric analysis. Their results revealed that the basic level factors reduced stunting levels through their influence on the underlying factors.

2.3 Methods of past studies on determinants of childhood stunting

Studies conducted in Zambia on the determinants of stunting have also analyzed the linear effects of the basic determinants of nutrition on stunting. Ngoma (2017) and Mzumara et al., (2018) focused on the linear impacts of these factors on the mean. Other researchers have also used models such as generalized linear and additive models (GLM and GAMs) (Umlauf, 2018). These linear models are advantageous because they are simple to estimate and interpret. However, if the outcome variable exhibits heterogeneity or extreme values and a linear relationship is implausible, they run the danger of mis-specifying the model and producing estimates that are inaccurate (Kneib, 2013). For instance, in the analysis of childhood stunting outcomes, the interest is in both maximum and minimum values and not just the conditional mean. Therefore, other methods that go beyond the mean have been used in studies of childhood malnutrition such as Quantile regression, and distributional regression (Gayawan, 2019; Kneib, 2013). In contrast, Moonga et al., (2021) and Kandala et al., (2001) analyzed the relationships between basic factors, and remotely detected characteristics and undernutrition in under-five children, using econometric models; with similar findings on the importance of mother's education, employment status, residence.

Studies conducted elsewhere have also applied several regression models to study child nutrition outcomes. These include Cox's regression, Poisson regression, simple and multiple logistic regressions, and ordinal logistic regression with findings on the importance of mothers' health, mother's education, place of birth, ethnicity, marital status, social economic status health-seeking behavior, and food security (Abuya et al., 2019; de Souza et al., 2012; Mocanu, 2013; Pedroso et al., 2021; Pradhan, 2010; Reurings et al., 2020; Senbanjo et al., 2019; Singh et al., 2019).

The literature also identifies Nutrition-specific and –sensitive programs identified that make use of determinants as a means to design nutrition programs. The Realigning Agriculture for Improved Nutrition (RAIN), Community Integration of Nutrition in Agricultural Programming and Critical Days Initiative (CDI) are some of the nutritional programs in Zambia. A study on the RAIN program found that while the program had positive effects on some determinants of child nutrition, there was no impact on stunting (Kumar et al., 2018). A study of a community-based package of interventions found that the interventions were associated with high HAZ score and decreased stunting (OR 0.68; 95% CI 0.36 to 1.28) (Rockers et al., 2016). The Community Integration of Nutrition in Agricultural Programming approach implemented in Zambia between 2013 and 2017 was associated with a reduction in stunting rates of about 7 percentage points (Corbett, 2018). An evaluation of the CDI found that while there were some declines in the prevalence of stunted growth in treatment districts, these reductions were not statistically significant (Brudevold-Newman et al., 2018).

From the literature, it is evident that several studies have pinpointed numerous probable causes and factors of stunting in children. However, these studies fall short of identifying the differences in the effects of the identified factors on stunting. Further, while studies in Zambia have focused on the basic factors of the UNICEF (1990) framework, very few studies have been done to analyze the marginal effects of underlying factors on child stunting. It is at these levels that integrated programs occur, and hence the literature also falls short of quantifying the marginal effects impacts that specific interventions may have on stunting rates. Marginal effects measure the effects on a particular outcome variable that results from changes in a specific independent variable(Gillespie et al., 2013; Harris et al., 2017b) while keeping other variables constant (Mize et al., 2019). They are commonly used in the field of economics to quantify the effects of independent factors on a particular outcome (Onukwugha et al., 2014). Marginal effects can therefore yield useful insights for the design of integrated nutrition programs.

2.4 Theoretical considerations and conceptual Framework

2.4.1 Theoretical considerations

As mentioned earlier, the UNICEF framework is the primary tool used in research to understand and analyze child nutrition. However, mathematical theories of the households are also relatively common in development economics (SchuXz,1984; Deolalikar, 1988), There are two main points of convergence in these theories. The first one is on the causes of malnutrition in children. Both recognize that the causes of child malnutrition comprise of proximal (immediate or direct) and underlying as well as basic determinants. The second point of convergence involves the classifications of determinants in to child characteristics, household level characteristic and community level characteristics.

The theoretical lens for this study is the child health production theory (Akin, 1992; Behrman & Deolalikar, 1988). The theory argues that child's health at a particular time is determined by a set consumer goods related to health, sets of determinants that impact the child directly (such as child's sex and age) including determinants that are unobserved that capture the child's initial health endowment (Akin, 1992). The theory posits that various inputs, such as parental education, income, and environmental conditions, play a vital role in producing child health outcomes. Based on the health production function and financial constraints, the household maximizes its utility. The change in child health given a change in determinants is given by the marginal effects function (Barrera, 1990). Other studies have used this theory (Todd & Wolpin, 2003; Bloom et al., 2004; Kutty, 2008; Agee et al., 2009; Barrera, 1990).

One of the primary alternatives to the Child Health Production Theory is the Social Determinants of Health (SDOH) framework. Unlike the Child Health Production Theory, the SDOH framework emphasizes the influence of broader social, economic, and environmental factors on health outcomes, including child health (Lundberg, 2020). While the Child Health Production Theory focuses on individual investments in health, the SDOH framework highlights the significance of structural determinants, such as income inequality, access to healthcare, and societal norms, in shaping child health disparities.

Critiques of the Child Health Production Theory center around its assumption of rational behavior and perfect information, which may not always hold true in real-world contexts. Moreover, critics argue that the theory oversimplifies the complex interactions among different determinants of child health and may not fully capture the role of cultural, social, and community influences (Frank et al., 2020; MacQueen, 2009; Inglis et al., 2018).

Despite its critiques, the Child Health Production Theory offers several advantages, particularly in understanding the individual-level determinants of child health. By focusing on the inputs that parents and caregivers invest in, the theory provides valuable insights into how household resources, such as education and income, directly impact child health outcomes (Lundberg, 2020). Additionally, the theory's emphasis on the long-term benefits of investing in child health aligns with the study's aim of exploring the factors influencing stunting prevalence in Zambia.

Given the study's focus on investigating the determinants of stunting in Zambia, the Child Health Production Theory is the most appropriate theoretical lens. Its individual-level approach and consideration of household investments in child health align with the research's specific context.

Moreover, as the study aims to understand the direct contributions of Food security, care practices, health environment, and other inputs on child health outcomes, the Child Health Production Theory provides a suitable framework for analyzing these relationships.

2.4.2 Conceptual framework

Further, the theory suggested by the conceptual framework is also the basis upon which probable determinants are identified. The theory postulates that the determinants of nutrition are related to one another in a hierarchical manner, such that direct determinants which directly affect nutrition are themselves affected by the underlying determinants which are also affected by the basic determinants (Black et al., 2013; UNICEF, 1990). Because of this link, it is possible to undertake independent studies for factors with various levels of causation.

This study, therefore, adapts UNICEF (1990) and the Lancet (2013) conceptual framework to analyze the marginal effects of the underlying factors of nutrition on child stunting in Zambia. Figure 1 presents the conceptual framework. The framework discerns between direct, basic, and underlying determinants. The direct determinants refer to diet and health condition at the individual child level. The diet includes the intake of micronutrients, protein, energy, and fat while health status refers to the health status of the child. In this case it specifically refers to the stunting status of the child. Health and diet are interdependent and influence each other. i.e children with inadequate intake of essential dietary elements are more susceptible to ill health and children with ill health are unable to absorb nutrients These are a result of underlying determinants. The underlying determinants comprising of food security, caring practices (mainly support and care during pregnancy), and health environment occur at the household level. Food security requires economic and geographical access to food. Care refers to the care given to both the children and their mothers during and before pregnancy. As it has been established that women are generally the caregivers of children, their health, mental health, diet are generally important in the health status of children. Health environment refers to the access of water and sanitation services as well as access to medical facilities.

The basic factors influence nutrition status through the underlying factors and occur at the regional level. They include the socioeconomic, ethnic, and political context in which a child's nutrition status is determined. Of these, the social economic status and income are particularly regarded as instrumental in curbing malnutrition. Apart from their effects on the ability to pay for nutrition, they are also necessary at the national level for provision of public services such as sanitation discussed under the underlying determinants.

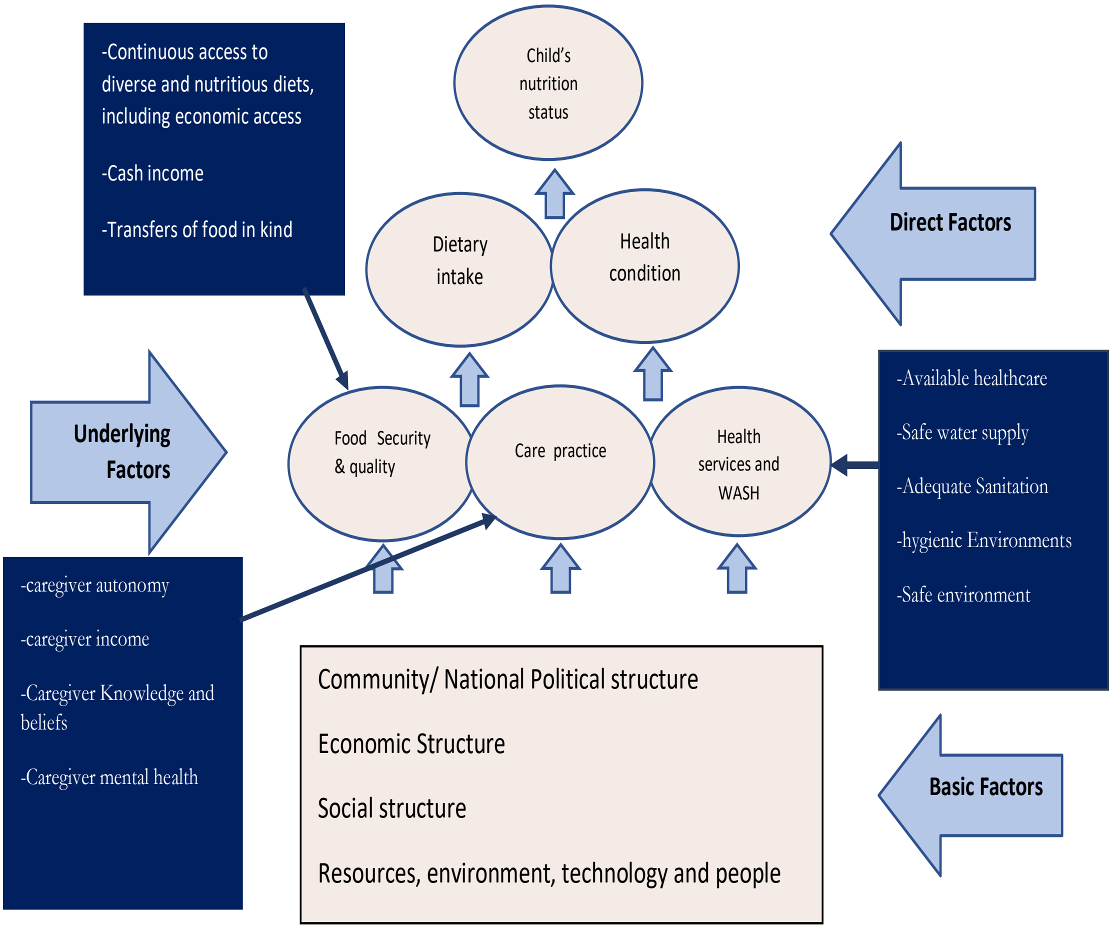

figure 1. Conceptual framework: modified from LANCET (2013) & UNICEF (1990)

3 RESEARCH STRATEGY, DESIGN, PROCEDURE, AND METHODS

In Section 1.2.1, the study posed three questions that this research report intends to answer—that is, 'What are the changes in stunting levels over the last 30 years?' and 'What are the determinants of childhood stunting and changes to these determinants in the last 30 years, and what are the marginal effects of the determinants on childhood stunting?' literature was reviewed to develop the conceptual framework that informed the selection of the approaches used in this study. This chapter describes the research strategy, design and data sources that were used to conduct the analysis. Generally, this chapter has three goals: to describe the research strategy (Section 3.1), the research design (Section 3.2), as well as the data sources and gathering (Section 3.3). The chapter also describes the variables under study (3.4) and the ethics, reliability and validity measures (Sections 3.5 and 3.6).

3.1 Research strategy

A research strategy gives information about how research objectives will be achieved. It is a plan of action for conducting a research study (Malhotra, 2017). Researchers normally distinguish between three research approaches (a)qualitative, (b) quantitative, and (c) mixed methods (Creswell, 2014).

This study utilized a Quantitative methods approach. According to Creswell (2014), a quantitative approach is one in which the researcher uses cause-and-effect thinking for developing knowledge. The researcher mainly uses postpositive claims to develop knowledge in a quantitative approach.

A quantitative approach uses research techniques like surveys and experiments, gathering information on pre-set instruments to produce statistical data (Creswell, 2014). The study therefore also adopted a postpositivist lens. Post-positivism challenges the notion of absolute truth and therefore researchers cannot be absolutely certain about their claims of knowledge when studying human behavior and action (Phillips & Burbules, 2000; Creswell, 2014). Thus, postpositivists study phenomena that indicate a need to investigate causes that influence outcomes.

According to Phillips and burbles (2000), Postpositivists make the anti-foundational assumption that knowledge is conjectural and that there will never be ultimate truth. As a result, research-based evidence is always imperfect.

3.2 Research design

ZDHS uses a cross-sectional research design. In a cross-sectional study, the outcomes and treatments are measured at the same time (Setia, 2016).

As a cross-sectional survey, the ZDHS used questionnaires and structured interviews to collect data, to generalize to an entire population (Babbie, 1990). The advantage of using survey data is that inferences can be made about some characteristics, attitudes, and behaviors of populations (Babbie, 1990).

3.3 Data Sources and data gathering

This study derived data from the Zambia Demographic and Health Survey (ZDHS), a representative data set at the provincial and country level. The ZDHS is the most comprehensive data set with nationally representative child and other health data in Zambia, and is carried out at intervals of approximately 5 years, allowing for comparisons across different survey rounds. It is conducted by the Zambia Statistics Agency together with partners from ministries, academic institutions as well as hospital laboratories (Statistics Agency Zambia, 2020) with additional funding provided by several international donors. Further, the ZDHS also received technical support from the DHS Program, a program that supports countries worldwide to undertake population and health surveys (Statistics Agency Zambia, 2020).

The ZDHS collects information on basic demographic and health variables through the use of standard structured and pretested questionnaires (ZDHS, 2018). It includes sections on nutrition and other health variables, child protection, education, as well as environmental variables. Specifically, the survey collects information on the health conditions of children and pregnant women, mortality levels (maternal and child), and gender, maternal and child nutritional status, fertility levels and preferences; contraceptive use and awareness regarding HIV/AIDS, ownership and use of mosquito nets, breastfeeding, maternal and childcare, children's immunizations, and childhood diseases, anemia incidence in women aged 15-49 and children age 6-59 months (ZDHS, 2018).

This study used ZDHS data from surveys conducted between 1992 and 2017/18. Specifically, the study utilized the "Children's recode (ZMKR71DT)" and Household recode (ZMPR1DT) datasets which included data of children aged 0–5 years. The ZDHS used a two-staged stratified sample design which involved the selection of sample clusters and households. The detailed sampling procedure was described elsewhere (Zambia Statistics Agency, 2020). The final analysis included 1,689, 1 998. 1,868, 5,119, 11,407, and 8,745 women of child bearing age and children below 5yrs from ZDHS 1992, 1996, 2001-02, 2007, 2013-14, and 2017/18, respectively (Table 1.). This study was restricted to children under the age of 5 rather than all children because this period is considered crucial for intervention (Haque, 2022).

DHS data is well suited to this study because it is a country-representative dataset that covers a wide range of the theorized determinants of child nutritional status. The DHS data set has been used by several other researchers (Akombi, 2017; Haque, 2022, Assefa, 2015). The permission and access to use the ZDHS data were granted by the DHS program. From the ZDHS data sets, it was possible to construct several definitions of access and use as discussed in the forthcoming section.

Table 1. Sample size by round of ZDHS survey.

Year	1992	1996	2001	2007	2014	2018
Sample size	1,689	1 998	1,868	5,119	11,407	8,745

3.4 Variables under study

3.4.1 Sampling and data extraction

As mentioned in the previous section, ZDHS data comes from a 2-stage cluster sampling procedure. The methodology section of the ZDHS contains a thorough explanation of the sampling process employed (ZDHS, 2018). This study adopted the Zambia DHS sample sizes.

The sample sizes are 1,689, 1,998, 1,868, 5,119, 11,407, and 8,745 for DHS rounds 1992, 1996, 2001, 2007, 2013-14, and 2018 respectively. The dependent variables extracted for use in the analysis are height /age measurements for children of children aged 0–59 months that were converted into stunting status during the analysis (see appendix 1.1).

3.4.2 Outcome variables

The outcome variable for this study was stunting status. Stunting is a symptom of retarded linear growth. It is used to refer to the failure of a child to reach expected height in comparison to children of the same age who are healthy and well-nourished (de Onis, 2016). The internationally accepted reference for stunting is by World Health Organizations Child growth Standard (WHO-CGS). A child is considered to be stunted if they have a measured height lower than -2 standard deviations (SDs) from the (WHO-CGS) median statistic for children their age (de Onis *et al.*, 2016; WHO, 2021). Similarly, a child with measured height below -3 SDs from the median of the WHO-CGS for the same age is considered to be severely stunted. This study will, however, only distinguish between children who are stunted and those who are not.

There are two main reasons for using stunting as an indicator of malnutrition in this study. Firstly, stunting is the most common manifestation of child malnutrition in Zambia, compared to wasting and underweight (Harris, 2017). Secondly, stunting is a long-term measure. It indicates chronic undernutrition over time and can therefore be distinguished from undernutrition brought on by temporary changes in dietary consumption or health (Onis, 2016; Smith, 2015). Onis (2016) also asserts that stunting accurately identifies inequalities in human development. It is therefore well suited to the analysis of factors over an extended time period.

The outcome variable of this study was dichotomized into two categories 1 for 'stunted' and 0 for 'non-stunted'. The two categories were defined according to the 2006 WHO standards for children using the height-for-age score.
Secondly, independent variables were finalized through the results obtained from the review of literature. Independent variables are discussed in the next section

3.4.3 Independent variables

In general, the selection of determinants in this study was informed by the Conceptual framework which was based on the UNICEF framework and Lancet framework developed in 1990 and 2013 respectively (UNICEF, 1990); Black et al., 2013) frameworks on child nutrition, the literature review, and their availability in data sets. Broadly, the variables are divided into three main categories, which include Food security, Care, and Health environment. Each of these variables is discussed in turn.

Under food security, Household dietary diversity - the count of distinct food categories eaten during specific time period is recommended as an indicator due to its association with improved nutrition outcomes specifically birth weight and child stunting. Food security, according to USAID, is "when all people have both physical and economic access to sufficient food to meet their dietary needs for a productive and healthy life at all times." Swindale and Bilinsky (2006) distinguish three elements that are crucial for achieving food security: the first is Food Availability which refers to individuals regularly having access to sufficient amounts of appropriate within reach of them or within a fair distance of them; 2) Food Access: social economic variables allow individuals to have adequate diet/nutrition level; 3) Food Utilization: proper use and handling of food, adequate knowledge of nutrition. While earlier versions of the DHS data sets provide data on household food consumption, the 2018 data set does not. This study, therefore, adopts the social economic perspective of food security which involves the use of the household's social economic status.

Earlier research has shown that household socioeconomic status, plays a substantial role in determining childhood nutrition. The social economic status of a household is assessed t hrough household assets and household income. This study employed the wealth index approach while also making using of household assets. The use of assets in determining household social economic status was developed by Filmer and Pritchett (2001). Despite being criticized for several reasons by many researchers (Poirier et al., 2019; Harttgen et al., 2013) it has been utilised by many researchers (Mohsena et al. 2010; Harttgen and Vollmer 2013; d'Errico et al., 2018). In order to make use of the asset index, this study uses the DHS asset module which is made up of household durables and infrastructure housing characteristics. Household durables include ownership of television, radio, motorcycle, bicycle, and car, while the household characteristics refer to access to electricity, main material used on the wall, floor, and roof. The asset index is constructed through Principle Components analysis (PCA). This ensures consistent results for all rounds of survey data being analysed. Including the asset index is beneficial as it caters for rural households where cash income is not always available.

For the care dimension, this study employs indices of parental education and count of children <5, mother's height, mother's BMI, and maternal anemia. Education of parents has long been associated with children's nutritional health (Webb & Block, 2004; Desai & Alva, 1998; Behrman & Wolfe, 1987) There are several potential connections, but parental education has an impact on a family's ability to earn money, withstand shocks, how well-informed they are about proper child care procedures, and, in the case of mothers, how much negotiating power they have within the household (Haque, 2018). While mothers are recognized as the primary caregivers due to the role they play in child birth and breastfeeding as well as the daily care of children (Ruel et al., 2013), this study analyses both maternal education and paternal education.
Several researches show evidence of trade-offs between quality of care for children and number of children (Jensen, 2012). findings on the subject reveal that the prevalence of stunting is low in households with fewer children. The study also shows evidence children born later are often neglected hence resulting in undesirable nutrition outcomes such as stunting (Jayachandran & Pande, 2013). The study employed count of children below 5 years old to capture the trade-off.
Further, the nutrition status of the mother has also been shown to have a significant influence on stunting Asefa (2015). The study therefore employed, mother's height (an indicator of earlier stunting) and mother's BMI as indicators of mother's nutritional status.

Finally, for health environment, the study considers measures that are crucial for maintaining a clean and hygienic environment, one that prevents the spread of diseases to infants. The study included the constructs water, sanitation, and health care. World Health Organization (2012) and UNICEF (2017), distinguish between improved and unimproved water sources. Improved water sources which are considered safe sources of water include surface water that is water that has been treated or not, coming from protected springs, standpipes or public taps, boreholes, piped water, protected drilled wells, rainwater, or bottled water.. Unimproved categories include unprotected wells, unprotected springs and untreated surface water and others. Recent work has also reignited interest in sanitation (Spears, 2013; Hathi et al., 2014). Sanitary facilities are broadly regarded as those that disrupt the faecal -oral pathway (Gleick, 2015). In this study, Sanitation is captured as households with improved toilet facilities according to WHO (2012) and UNICEF (2017). WHO and UNICEF Sanitation facilities are regarded as improved sanitation if they: are not shared and pour flush/flush to pit latrines, sewerage systems or septic tanks; composting toilets pit latrines that are improved in terms of ventilation or addition of a slab (DHS, 2023). Facilities that flush elsewhere other than to a septic tank, pit latrine or sewer system, septic tank, are classified as unimproved (DHS, 2023).

The third dimension of health environment, could considerably enhance mother and child health in general and provide access to interventions which are specific to nutrition, such as recommendations on how to feed infants. This study measures health access as 'born in medical facility'. It employs a dummy equating one with yes response. The child's place of birth has been used as an indicator in many studies for access to numerous other health services and treatments such as (e.g. postnatal care, access to nutrition knowledge, and vaccinations). These variables make up the core of this research. However, the study also included control variables for the purpose of improving the precision of the estimates and to reduce correlation between the selected determinants and the disturbance term. The study therefore includes variables such as child age, child sex, child's BMI, and mothers age. Parental education, asset index, wealth index, sanitation, source of drinking water, mothers nutritional status, count of children <5, and access to health services, formed the core of this study's analysis.

3.4.4 Statistical Analysis

This study was based on secondary data from the Demography and Health Survey. The datasets were used to estimate the magnitude of the effects of determinants of childhood stunting. The Kids Record (ZMKR) files and household (ZMPR file), which contain information about the health of children and women, were used to conduct the analysis. The two files were merged to create one file for each year in the analysis. In terms of data extraction, the study extracted the variables according to the discussion in section 3.4.2 and 3.4.3 above. The study used STATA (Statistical software) to analyse the data. Once data was entered into STATA, it was checked for inconsistencies and missing values, and descriptive statistics were done. To summarize the characteristics of the study participants, descriptive analyses were carried out, and the results were presented using text, tables, and graphs. The study employed stunting status as the dependent variable while the determinants of child stunting identified in the literature review were used as the independent variables.

Due to the binary nature of the selected outcome variables, logistic regression was used to examine the determinants' relationship with stunting. This approach has been used in studies to determine predictors of several nutrition and health outcomes (Zhao et al., 2015; Yusuf et al., 2019; Khan et al., 2020; Haque, 2022). Binary logistic regression is a regression analysis that is carried out when the dependent variable is dichotomous (with only two possible value outcomes), with levels representing a category to which the outcome belongs (Hosme et al., 2013). First, the bivariate association was investigated using simple logistic regression analysis followed by multiple logistic regression. While the descriptive analysis used data from all rounds of the ZDHS, the logistic analysis was restricted to data from the 2014 and 2018 ZDHS data sets due to inconsistently measured variables in the other rounds of the survey. Both the adjusted and unadjusted odds ratio and the respective 95% confidence intervals were depicted to show the strength of the relationship. Determinants with a p-value of < 0.05 were considered statistically significant. Using a significance level of 5% in statistics is a common practice to strike a balance between Type I errors (false positives) and Type II errors (false negatives). According to Johnson and Smith (2018), a 5% significance level is widely adopted in research due to its convention, practicality, and ease of comparability across studies. It allows researchers to minimize the risk of claiming a significant effect when none exists, while still maintaining an acceptable level of statistical power to detect meaningful relationships or differences in their data.

For this study the outcome variable was as follows stunting=1 if stunted; stunting =0 if non-stunted. As a result, the analysis was therefore attempting to predict the stunting outcome category (1) as a function of the determinants identified in the literature review section:

$ST_t = f(SEC_t, par\_ed_t, safew_t, sanit_t, heas_t\ mt_t\ bt_t)$……………………………………………….(1)

Where:

SEC, is social economic status measured by wealth index

par_ed is parents education measured by whether or not the mother and father exceeded secondary education

$safew_t$ is the type of water source used by the household and is measured by whether it is improved or not.

$sanit_t$ is the type of toilet used by the household (improved or not)

$heas_t$ represent Health environments is measured by whether or not the child was born in a health facility.

Mt is mothers height measured in centimeters

Bt is child's birthweight measured in grams

STATA was used to convert the functional equation into an econometric Logistic Regression Equation.. The Logistic model is one of the techniques that can be employed to estimate a model in which the dependent variable has a binary outcome (Hosme et al., 2013), in this study, whether the child is stunted or not. In the context of binary logistic regression, the focus was therefore be on the probability of membership in a target category (stunted)

Logistic P(ST)= $\alpha+\beta_1$ SEC_t + $\beta_2 paed_t$ +$\beta_3 par\_ed_t$+ β_4 $safew_t$ + $\beta_5 sanit_t$ + $\beta_6 heas_t$ + ε………(2)

Where;

Stunting = $\begin{Bmatrix} 1, if\ stunted \\ 0, if\ \text{non}-stunted \end{Bmatrix}$ …

Where logitic P(ST) is the likelihood of stunting when the independent variables change. On the other hand, the coefficients (β_i) indicate the change in the probability of stunting for one-unit change in the independent variables. The model was therefore used to estimate the probability of stunting status =1 relative to the probability that stunting status= 0. The probability of a non-stunted child was therefore taken as 1-p.

Since $p = Lr(ST = 1|X) = F(X'\beta)$………………………………………………. (3)

Then;

$\rho = \frac{\exp\ (X\prime\beta)}{1+exp\ (X\prime\beta)}$…………………………………………………………………….. (4)

As a result, the predicted logistic model will be:

$Lr[\ ST_i\ \ 1|x_i$ =(parents' education, mother's height, birthweight, wealth index, and place of residence, source of drinking water, mother's age, preceding birth interval, cooking fuel, and place of birth ………………………………………………………………………………….(5)

As a result, the model's predicted values fall within the range of 0 to 1. Estimates of the Logistic model were made using maximum likelihood estimation (MLE). The parameter values provided by MLE make the observed sample the most likely sample out of all possible samples (Miura, 2011).

The next step was to analyze the marginal effects (ME) of the determinants of stunting status (ST). The ME shows how the probability changes when the independent variables increase by one unit (Torres, 2014). In this study, the change is from 0 to 1. The marginal effects for the logistic model are therefore given by:

$$\frac{\partial y}{\partial x_j} = \wedge(X'\beta)[1 - \wedge(X'\beta)]\beta_j \ = \frac{e^{X\prime\beta}}{(1+e^{X'\beta})^2}\ \beta_j$$

Goodness of fit

In evaluating the model, the analysis focused on 2 levels; the overall fit of the model in relation to the data, and the individual predictors in the model.

Additionally, p-values were utilized to assess the significance of the independent variables in the model. A p-value less than 0.05 indicates statistical significance, implying that the independent variable has a significant impact on the model. Conversely, a p-value greater than 0.05 indicates that the independent variable is not statistically significant within the model (Hosmer et al., 2013).

For the Overall fit, the Hosmer-Lemeshow test was used to evaluate the goodness-of-fit. The focus of this test was therefore on the chi-square value to assess whether the model that contains the independent variables represents a substantial improvement in fit over the null model with no independent variables. A good model fit refers to a model that accurately approximates the dependent variable in relation to the independent variables. If the Hosmer–Lemeshow statistics result in a nonsignificant chi-square value, the model is considered a good fit. However, if the Hosmer–Lemeshow statistics produce a significant chi-square value, the model is considered a poor fit.

Additionally, p-values were utilized to assess the significance of the independent variables in the model. A p-value less than 0.05 indicates statistical significance, implying that the independent variable has a significant impact on the model. Conversely, a p-value greater than 0.05 indicates that the independent variable is not statistically significant within the model (Hosmer et al., 2013).

3.5 Ethics

The data utilized in this study is secondary data and was availed by the DHS program to undertake this study. The data does not include any information that may be used to identify study participants personally. In this regard, an ethics waiver was requested and obtained (see appendix 3).

3.6 Validity, reliability, dependability

As the study made use of secondary data (DHS), the main assumption was that the data has already undergone the process of tool validation. However, Construct validity is considered important when a study uses secondary data sources. Construct validity refers to the identification of study participants, contexts, causes, an d effects in a study (Reichardt, 2005). Therefore, as a first step to ensuring validity, the researcher ensured that suitable data is extracted from the DHS data based on theoretical specifications acquired from the literature review. On the other hand, reliability is the consistency and predictability of an assessment tool's results (Stephanie, 2016). Reliability was determined through the use of appropriate statistical measures.

Dependability refers to the consistency of study outcomes and the level to which research techniques are documented, making it possible for people outside the study to observe, review, and criticize the study procedures (Moon et al, 2016). Dependability was ensured by documenting the methodology and methods employed in the study and all applicable information pertaining to the study.

4 PRESENTATION OF RESEARCH RESULTS

This section presents the research results of this study obtained from the research methods and procedures articulated in section 3. Section 4.1 presents the general characteristics of the research population. Section 4.2 details the prevalence of stunting between the years 1992 and 2018. Section 4.3 looks at the trends in the underlying determinant of childhood stunting. Section 4.4 is about the determinants associated with childhood stunting while section 4.5 is about the marginal effects of the underlying determinants.

4.1 General Characteristics

The general characteristics of children under the age of 5 are given in Table 1. Although the proportion of children living in urban regions has increased over the years, the statistics of children under the age of five who reside in rural regions remains substantially larger. Between the years 1992 and 2018, the statistics of children living in urban regions increased by 4.9%. The majority of respondents in the surveys (mothers) between 1992 and 2018 were in the age category 30 to <50y, while the year 2001 had a higher percent of respondents in the age category 15 to <25y. The number of people in the poorer and poorest increased between the years 1992 and 2018 from 15.8%- to 28.4% and from 17.4% to 24.1 respectively. On the other hand, those in the richer and richest reduced from 24.3% to 14.8% and 22.3% to 13.0% respectively. Maternal secondary education between the years 2001 and 2018 increased from 18.1 to 31.1%

4.2 Levels and Prevalence of Stunting

This study, used the ZDHS 1992 to 2017/18 data, to highlight detailed stunting prevalence at the geographic level for children under the age of five was examined. The level of stunting among children under 5 was 39.1%, 41.5%, 47.7%, 44.0, 39.6 and 34.9% in the 1992, 1996, 2001, 2007, 2014, and 2018 surveys, respectively.

The level of stunting declined by 4 percentage points between 1992 and 2018. Comparing these statuses among provinces in Zambia, the study found that the prevalence of childhood stunting in the Northern and Luapula provinces was worse than in any other province (Figures 1 and 2). Further, the study also found that the number of children that are stunted is higher in rural areas compared to urban regions for all rounds of the ZDHS.

Table 2. General characteristics of children under 5 segregated by year of the ZDHS.

Variables n %			ZDHS YEAR			
	2018	2014	2007	2001	1996	1992
Stunting prevalence (%)						
Stunted	34.9(3,053)	39.6 (4,512)	44.0 (2,255)	47.2 (2,565)	41.5 (780)	39.2 (662)
Non-stunted	65.1 (5,693)	60.5 (6,895)	56.0 (2,866)	52.8 (2,865)	58.5 (1.098)	60.8 (1,027)
Maternal age						

1. 15 to <25y	34.7 (3,456)	31.0(4,176)	34.7 (3,456)	37.6 (2,584)	44.6 (891)	44.9 (799)
2. 25 to<30y	23.6 (2,345)	26.0(3,497)	23.6 (2,345)	26.3 (1,810)	22.8 (455)	22.5 (401)
3. 30 to <50y	41.7 (4,156)	43.0 (5,780)	41.7 (4,156)	31.1 (2,483)	32.7 (653)	32.6 (581)
Child sex						
Male	49.8 (4,958)	50.7 (6,828)	49.7(3,181)	50.3 (3461)	48.0 (960)	50.0 (891)
Female	50.2 (5,001)	49.2 (6,629)	50.3 (3,220)	49.7(3,416)	62.0 (1,039)	60.0 (890)
Residence						
Urban	30.0 (2,986)	37.15 (4,998)	44.5 (3,178)	25.1 (1,725)	32.7 (653)	43.1 (767)
Mother level of education						
no education	10.8 (1,070)	11.2 (1,509)	10.4 (741)	15.5 (1,067)	14.3 (285)	16.4 (292)
1. primary	52.1 (5,188)	55.6 (7,477)	53.3(3,805)	64.6(4,445)	65.5 (1310)	63.4 (1,129)
2. secondary	33.1 (3,293)	29.6 (3,981)	33.4(2,242)	18.5(1,272)	18.9 (378)	18.6 (332)
3. higher	4.08 (406)	3.5 (475)	5.1 (358)	1.4 (93)	1.3 (26)	1.6 (28)
Father level of education						
0. no education	6.5 (503)	6.6 (804)	7.2 (373)	67.3 (475)	7.5 (140)	8.2 (133)
1. primary	38.9 (2,994)	41.7 (5,108)	42.7 (2,223)	52.1 (3,374)	49.4 (917)	48.7 (792)
2. secondary	42.8 (3,297)	41.9(5,137)	38.3(1,991)	34.4(2,227)	36.7(689)	38.0 (617)
3. higher	7.8 (598)	6.9 (840)	9.4 (490)	5.1 (327)	5.1 (94)	4 (65)
8. don't know	3.9 (304)	2.9(359)	0.3 (109)	1.2(78)	1.3 (24)	1.2 (19)
wealth Index						
1. poorest	28.4(2,826)	23.8(3,197)	15.8(1,131)	-	-	-
2. poorer	24.1(2,395)	23.9(3,215)	17.4(1,245)	-	-	-
3. middle	19.7(1,961)	22.8(3,063)	19.7(1,409)	-	-	-
4. richer	14.8(1,477)	17.0(2,282)	24.3(1,733)	-	-	-
5. richest	13.0(1,298)	12.6(1,696)	22.3(1,628)	-	-	-

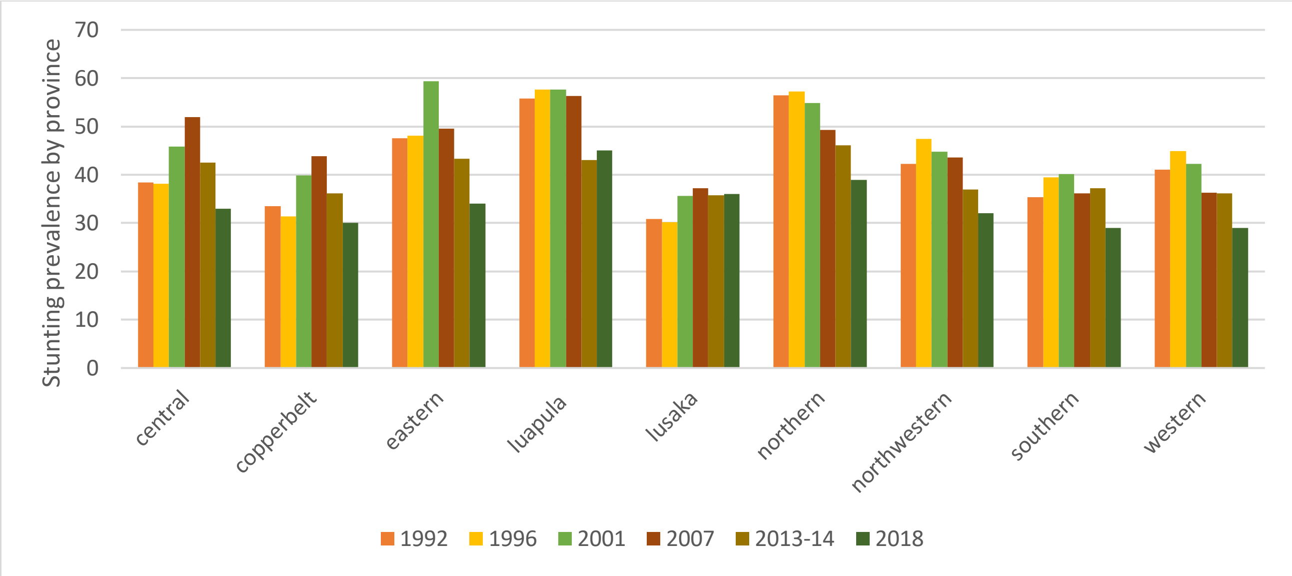

Figure 2. Stunting level in children <5 segregated by province and year of the ZDHS.

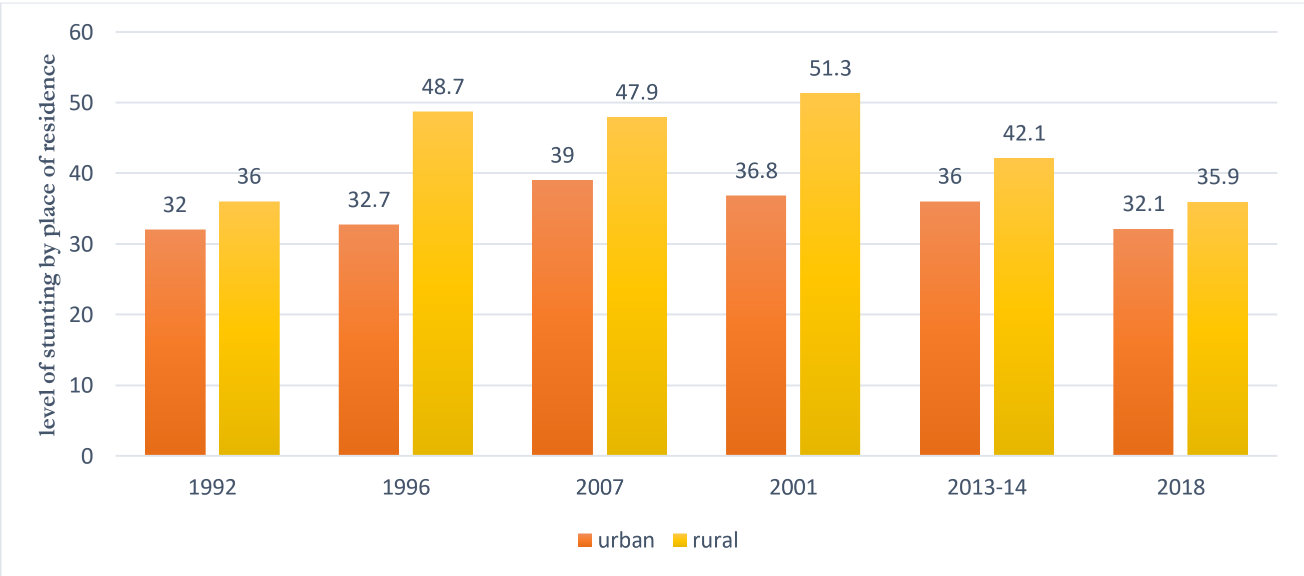

Figure 3. Levels of stunting in children <5 years old by place of residence and round of the ZDHS.

4.3 Trends in the Determinants of stunting

Table 3 presents the trends in stunting prevalence in children under 5 years old and the determinants used in this study from 1992 to 2018. Over this period, the stunting prevalence exhibited a modest reduction of 4.1%. Notably, the most significant change among the determinants was observed in the number of children born in health facilities, which increased by 32%. Additionally, there was a substantial improvement in access to improved sanitation (toilets), with an increase of 29.5%. In contrast, maternal education showed relatively slower progress, with an incremental change of only 5.9% in access.

4.4 Determinants of childhood Stunting and their association with childhood stunting

In order to see the association of determinants on childhood stunting, the study used Binary Logistic Regression. Wealth index, place of residence, mother's education, number of children<5, source of drinking water, sanitation, maternal height, maternal BMI, asset index, and place of birth were the determinants that were observed to have a significant relationship with stunting based on their p–values being < 0.05 in the bi-variate analysis.

Table 4 presents the adjusted odds ratio and unadjusted odds ratio which depict the determinant's association with childhood stunting. The pseudo-R2 statistic was 0.0392. The goodness-of-fit, Hosmer–Lemeshow chi-square test statistic was 10.41 with a p-value = 0. 0.2372 indicating good model fit.

According to the wealth index (indicating SEC), the children from households in the poorest index, poorer index, middle index, and richer index had odds ratios of 1.76, 1.5, 1.49, and 0.81 at the 95 % confidence interval respectively using the richest as reference. All categories of the wealth index had a p-value<0.000.

Maternal level of education below secondary, maternal age, source of drinking water, Place of birth were also significantly related to childhood stunting with odds rations (1.14 (95% CI: 1.04, 1.25), (1.13 (95% CI: 1.05, 1.23), (1.11 (1.02, 1.20), (1.19 (95% CI:1.09, 1.30) respectively.

The likelihood of a child being stunted (AOR = 1.07; 95%CI: 0.81, 1.42; p-value < 0.638) is higher for children with shorter mothers in comparison to those whose mothers had a normal to high stature (Table 2). Further, children of young mothers, i.e < 25 were more likely to be stunted (odds ratio 1.13 at 95%CI, p-value=0.002).

Household characteristics were also found to be important in determining stunting. Children from households that use unimproved cooking methods were at higher odds of stunting (OR=1.39 (1.15, 1.68; p-value<0.001).

Additionally, while the determinants working status, number of children <5, sanitation, paternal level of education, maternal BMI, decisions were observed to be significant in simple logistic analysis, they lost explanatory power in multiple logistic regression and became insignificant. The p-values in multiple logistic regression for working status, number of children <5, sanitation, paternal level of education, maternal BMI, decisions were 0.055, 0.540, 0.07, 0.897, 0.638, 0.336 while all had p-values less than 0.005 in simple logistic regression

Table 3. Changes in the underlying Determinants between 1992 and 2018

Year	Stunting	Maternal education %	Paternal education %	Antenatal visits %	Born in a hospital facility%	access to improved toilet %	Access to improved drinking water %	Noc (n)	P_BI
1992	39.19	43.04	42.41	73.93	50.03	75.62	55.27	4	36.6
2018	34.9	37.15	52.69	65.2	82.41	46.08	64.11	35.51	43.0
change	4.29	5.89	-10.28	8.73	-32.38	29.54	-8.84	18.38	

Table 4. Determinants of the stunting status of children <5 years

	Unadjusted 0R 95% CI	p-value	Adjusted OR 95% CI	p-value
Maternal Education				
Secondary or above	Reference		Reference	
Below secondary	1.45 (1.36, .54)	0.000	1.14 (1.04,1.25)	0.004
Residence				
Urban	Reference		Reference	
Rural	1.23 (1.16, .31)	0.000	0.81 (0.73,0.90)	0.000
Wealth Index				
Richest	Reference		Reference	
Poorest	2.39 (2.14, .66)	0.000	1.89 (1.47, 2.44)	0.000
Poorer	2.08 (1.86, .32)	0.000	1.76 (1.39, 2.22)	0.000
Middle	1.77 (1.58, .97)	0.000	1.50 (1.23,1.82)	0.000
Richer	1.70 (1.52, .92)	0.000	1.49 (1.27, 176)	0.000
Childage in Months	1.01 (1.01, .01)	0.000	1.01 (1.00, 1.01)	0.000
Child sex				
Female	Reference		Reference	
Male	1.26 (1.19, .34)	0.000	1.28 (1.20, 1.38)	0.000
Born in medical facility				
Yes	Reference		Reference	
No	0.77 (0.72, .82)	0.000	1.19 (1.09, 1.30)	0.000
Asset Index	0.91 (0.88-0.94)	0.000	0.99 (0.85-1.17)	0.980
Number of children <5	1.09 (1.05, 1.12)	0.000	1.01 (0.97, 1.06)	0.540
Birthweight				
>= Normal Birthweight	Reference		Reference	
Low birth weight	0.47 (0.42, 0.53)	0.000	0.44 (0.38, 0.51)	0.000
Birth -interval				
Normal birth interval	Reference		Reference	
Short birth interval	1.36 (1.25, 1.49)	0.000	1.27 (1.15, 1.41)	0.000
Sanitation				
Improved	Reference		Reference	
Unimproved	1.17 (1.10, 1.24)	0.000	0.93 (0.85, 1.01)	0.070
Child BMI	1.00 (1.00, 1.00)	0.000	1.00 (1.00, 1.00)	0.000
Source of drinking water				
Improved	Reference		Reference	
Unimproved	1.30 (1.22, 1.38)	0.000	1.11 (1.02, 1.20)	0.014
Paternal Education				
Secondary and above	Reference		Reference	
Below secondary	0.79 (0.74, 0.84)	0.000	0.99 (0.92, 1.08)	0.897
Maternal Height				
>150cm	Reference		Reference	

	Unadjusted 0R 95% CI	p-value	Adjusted OR 95% CI	p-value
<150cm	0.43 (0.38, 0.48)	0.000	0.49 (0.42, 0.56)	0.000
Maternal BMI				
Normal and above	Reference		Reference	
Low BMI	1.53 (1.20, 1.94)	0.001	1.07 (0.81, 1.42)	0.638
Roof				
Improved	Reference		Reference	
Unimproved	1.43 (1.35, 1.51)	0.000	1.02 (0.92, 1.14)	0.709
Floor				
Improved	Reference		Reference	
Unimproved	1.46 (1.37, 1.55)	0.000	1.03 (0.90, 1.18)	0.649
Wall				
Improved	Reference		Reference	
Unimproved	1.22 (1.15, 1.29)	0.000	1.08 (0.99, 1.18)	0.083
Cooking fuel				
Improved	Reference		Reference	
Unimproved	2.22 (1.94, 2.55)	0.000	1.39 (1.15, 1.68)	0.001
Decision maker				
Yes	Reference		Reference	
No	1.15 (1.08, 1.23)	0.000	1.04 (0.96, 1.12)	0.336
Work status				
Works	Reference		Reference	
Does not work	0.92, (0.87, 0.97)	0.005	0.93 (0.87, 1.00)	0.055
Mother's age				
Above 25	Reference		Reference	
Below 25	1.11 (1.04, 1.18)	0.001	1.13 (1.05, 1.23)	0.002

4.5 Marginal effects of the Determinants of childhood stunting

Table 5. shows the Marginal effects of the Determinants of childhood stunting. In order to interpret the coefficient of the Logistic model, the analysis took the marginal effects of the determinants on stunting status.
The study found that wealth index, maternal education, birth weight, maternal height, cooking fuel, birth interval, child sex, residence, place of birth, mother's age, sanitation, and source of drinking water had the highest marginal effects on stunting.

The study found a significant reverse relationship between stunting and maternal education. The coefficient of maternal education was -0.0352223, meaning that a percentage increase in secondary and above education will reduce stunting probability by 3%. Similarly, an inverse relationship was found between stunting and maternal height, birth interval, access to medical facilities, wealth index, source of drinking water, age, and birth weight with coefficients -0.1619682, -0.05346, -0.0351417, -0.034418, -0.0227381, -0.0280467, -0.1802763 respectively. A percentage increase in these determinants will reduce childhood stunting by 16, 5.3, 3.5, 3.4, 2.3, and 18 percentage points respectively. On the other hand, the study observed a that child age and sex were positively associated.

Additionally, paternal education had the smallest effect on childhood stunting, with a coefficient of 0.0025471, followed by the variable number of children under 5 and women's empowerment variable 'decisions' with coefficients -0.004043 and 0.00608 respectively.

Table 5. Marginal effects of the Determinants of childhood stunting

		Delta-method					
		dy/dx	Std. Err.	Z	p-value	[95% Conf.	Interval]
Maternal Education		-0.03522	0.010129	-3.48	0.001	-0.05507	-0.01537
Place of Residence							
	Urban	Reference					
	Rural	-0.05034	0.011563	-4.35	0	-0.073	-0.02768
Wealth Index		-0.03442	0.006517	-5.28	0	-0.04719	-0.02165
ChildAge		0.001437	0.00023	6.24	0	0.000986	0.001888
Childsex							
	Female	Reference					
	Male	0.05251	0.007787	6.74	0	0.037247	0.067773
Place of birth		-0.03514	0.009322	-3.77	0	-0.05341	-0.01687
Birthweight		-0.18028	0.016166	-11.15	0	-0.21196	-0.14859
Birth interval		-0.05346	0.011664	-4.58	0	-0.07632	-0.0306
Sanitation		0.022603	0.009078	2.49	0.013	0.004811	0.040396
Source of drinking water		-0.02274	0.008879	-2.56	0.01	-0.04014	-0.00534
Maternal Height		-0.16197	0.016971	-9.54	0	-0.19523	-0.12871
Cooking		-0.09544	0.019018	-5.02	0	-0.13271	-0.05817
Work status		0.01599	0.008016	1.99	0.046	0.000278	0.031701
Maternal age		-0.02805	0.009133	-3.07	0.002	-0.04595	-0.01015

5 DISCUSSION OF RESEARCH FINDINGS

This research set out to investigate the determinants of childhood stunting in Zambia. To achieve this, the research pursued three questions. The first was to capture the changes in child stunting in the last 30 years. The second was to identify and measure trends in determinants of childhood stunting in the last 30 years. And the third was to estimate the marginal effects of the determinants on childhood stunting in Zambia.

As a result, the findings reported in chapter 4 are interpreted in this section using the conceptual framework proposed in chapter 2. Section 5.1 Discusses the determinants associated with stunting while the marginal effects of the determinants of stunting are discussed in section 5.2.

5.1 Determinants of nutrition associated with stunting

The period 0-59 months is a critical time and forms the basis for lifelong optimum health, growth, and neurodevelopment (black et al, 2013). The impact of nutrition on potential and future health is highest during this time. Without sufficient nutrition, physical growth is inhibited and intellectual development is slowed (Ruel et al, 2013). Inadequate nourishment during this time causes irreparable harm to a child's developing body and brain (Black, 2013). Therefore, the analysis of the children's nutrition is vital since it not only affects the health but also the child's productivity and overall potential in the long run (Ruel et al, 2013).

Regarding the determinants of nutrition associated with stunting, this study indicated that parents' education (especially mothers), mother's height, birthweight, wealth index, and place of residence, were significantly associated with stunting. Similarly, the source of drinking water, mother's age, preceding birth interval, cooking fuel, and place of birth were significantly associated with stunting.

This study reveals that children living in poor households face higher odds of stunting. Limited earning capacity in such homes often results in inadequate dietary intake, as they have less resources to spend on a nutritious diet, and are at a higher risk of infection with limited access to necessary medical care services (Menon, 2012). Cross-sectional studies have produced similar findings in Nigeria (Akombi, 2017), Iran (Kavosi, 2014), and Nepal (Tiwari, 2014). According to the results of a prior study, the risk of stunting is twice as high in children from poorer families compared to their richer counterparts (Haque 2022).

The link between household economic status and childhood stunting is intrinsically tied to food security, as households with lower socioeconomic status are more prone to food insecurity (Paudel, 2012). This confirms the conceptual framework of this study, highlighting that the determinants of stunting are hierarchically related. And in this case, the social economic status influences stunting through its impact on food security. Further, the likelihood of stunted growth in children decreases with a rise in the wealth index. This supports the notion that an increase in social economic status will lead to a reduction in stunting prevalence (Menon, 2012).

Cross-sectional studies have produced similar findings in Nigeria (Akombi, 2017), Iran (Kavosi, 2014), and Nepal (Tiwari, 2014). According to the results of a prior study, the risk of stunting is twice as high in children from poorer families compared to their richer counterparts (Haque 2022).

The results also highlight that the probability of childhood stunting was lower in the rural areas in comparison to the urban areas (OR 0.81 (p-value < 0.000). These findings diverge from several studies undertaken elsewhere such as in Ethiopia and Bangladesh. For instance, an Ethiopian study found that a child in a rural area is more likely than a child in an urban area to experience chronic energy deficiency (Assefa, 2015). Similar findings were reported in Ghana (Darteh, 2014). These studies attributed the high likelihood of stunting in rural areas to lower levels of education, socioeconomic deprivation, limited access to drinkable water, high incidence of infectious diseases, and low nutritional awareness than urban areas (Akram, 2000; Akram, 2018; Haque, 2022).

Additionally, this study found that the number of stunted children was higher in Luapula and Northern provinces which are predominantly rural. Prior research in Zambia by Kandala (2019) found that children from the province of Luapula had a higher prevalence of stunting than children from other provinces, which aligns with this study's findings.

In examining the care variable, the research revealed significant associations between childhood stunting and several factors, including maternal education, the number of children under five, birth weight, and mother's height. Notably, maternal education below the secondary level was found to be significantly associated with higher odds of stunting, corroborating similar findings in previous studies conducted in Ethiopia (Girma, 2002), Kenya (Abuya, 2012), and Tanzania (Happiness, 2010). These consistent results indicate the pivotal role of maternal education in addressing childhood stunting.

The positive relationship between maternal education and child health outcomes can be attributed to several factors. Education equips women with the knowledge and skills necessary for better childcare and feeding practices (Yimer, 2010). It enhances their capacity for information processing, independent decision-making, and negotiation within the household context (Assefa, 2015). Moreover, educated mothers are more likely to utilize healthcare facilities effectively, communicate with medical professionals, and adhere to recommended treatment regimens, ultimately contributing to improved child health (Abuya, 2012).

Furthermore, maternal education leads to positive changes in resource allocation, benefiting children's nutrition and overall well-being (Haque, 2018). Educated mothers are more inclined to adhere to recommended feeding practices, resulting in increased dietary diversity, frequency of meals, and nutritional quality for their children (Raj, 2010). Additionally, they adopt essential childhood survival strategies such as optimal breastfeeding, family planning, and immunization, breaking the cycle of ignorance and fostering better health outcomes for their offspring (Senbanjo, 2011).

In contrast, the study found that father's education was not as strongly associated with childhood stunting as mother's education. Notwithstanding this, the study emphasizes a positive relationship between parental education and child nutrition (Akombi, 2017).

The results of this study also revealed that children whose mothers were nutritionally deficient (indicated by body mass index (BMI) and maternal height) are at a higher risk of stunting. Previous research supports the influence of maternal BMI on stunting outcomes and the trans-generational impact on stunting initiation during pregnancy (Nair, 2016; Kalavani, 2018; Senbanjo, 2013). Maternal BMI significantly affects early childhood nutritional status, which can contribute to stunting, including low birth weight (Haque, 2022).

Additionally, the study also found a significant relationship between stunting and mother's height. Other studies conducted elsewhere have also found relationships between childhood stunting and several indicators of mothers' nutritional deprivation. Moreover, women with compromised nutrition status who exhibit low BMI, who are short or have micronutrient deficiency are more likely to give birth to light weight babies, produce lower quality breastmilk, and have a greater risk of mortality due to postpartum hemorrhage (WHO, 2017).

The effects of the maternal nutrition status begin during pregnancy and continue for a few months post-delivery when the newborn is entirely dependent on their mother for nutritional needs (Chirande, 2015; Terefe, 2015; Haque, 2022). In addition to this, a study found that birthweight increased by 206g in non-stunted mothers compared to birthweight in stunted mothers. Other studies found that maternal stunting was a significant predictor of stunting in children (Haque et al, 2022; Bisai, 2010). This can be attributed to the existence of an intergenerational link between mothers and children, which entails that small mothers would have smaller babies, who will end up being small mothers as well (Dessie, 2019; Teller, 2000). This supports the findings in this study which indicated that children of short mothers had higher odds of stunting.

Regarding the number of children living in the same household, the study revealed that a high count of children living in the same home, especially those below 5 years old is associated with stunting. Mothers with more young children are less likely to pay attention to lower-level children. This result is consistent with research from East Africa (Tamirat et al., 2021). Similarly, the preceding birth interval was also found to be a significant predictor of childhood stunting. Compared to children who had a birth interval of at least 24 months, stunting risk was higher in those that had a lower birth interval. Research conducted in Bangladesh supports these findings (Das, 2011). Close proximity of birth reduces attention given to children and also has an impact on resources available for childcare. Further, close proximity of births has also been known to reduce breastfeeding period which is also important determinant for child nutritional status (Tamirat et al., 2021; Dessie, 2019).

When it comes to the Health environment dimension, the study identified a significant relationship between household source of drinking water and access to health services. However, the study found a weak relationship between sanitation facilities and childhood stunting. The study found that the odds of being stunted in homes that could access water from an improved source were less than the odds of stunting in homes with no improved water source. These findings coincide with those of a Nigerian study (Akombi et al, 2017), supporting the role of improved water sources in reducing stunting prevalence.

In contrast, the study found that sanitation was not a strong determinant of stunting. This finding disagrees with a number of studies. For instance, Fink et al. (2011) reported that the odds of stunted growth were lower in homes that could access sanitation which is improved. Additionally, multiple studies in India, Ethiopia, and Peru emphasized the crucial role of improved sanitation in enhancing children's nutritional status, particularly reducing stunting (Rah, 2015; Spears, 2013; Checkley, 2004; Fenn, 2012).

Studies conducted by Hall (2008), Dangour (2013) Briend (1990), and Humphrey (2009), indicate that poor water and sanitation (WASH) practices and facilities can lead to diarrhea, intestinal worm infections, or environmental enteropathy, all of which can have an influence on children's nutritional status. Nonetheless, the findings of this study are supported by several others (Suri et al., 2014; Dearden et al., 2017; Woodruff et al., 2017; Buisman et al., 2019), suggesting a poor relationship between sanitation and stunting. One plausible explanation for this discrepancy could be that infants, at this age, are unlikely to be in direct contact with sanitation facilities as they are highly dependent on their mothers.

The results of this study demonstrated that the child's place of birth is a highly important predictor of the stunting status of children. In comparison to children born in a medical facilities, children who were born in any place other than a medical facility were at higher odds of stunting. This echoes the results of cross-sectional research carried out earlier in India and Nepal which also reported high rates of stunting among children born at home in comparison to those born in a medical facilities (Tiwari, 2014; Biswas, 2011). The association between place of birth and stunting status may be attributed to a knowledge gap regarding recommended child-feeding practices and poor healthcare-seeking behavior of the mothers (Girma, 2002; Akombi, 2017). Children born in medical facilities are likely to receive better immediate postnatal care and support, including breastfeeding initiation, immunizations, and access to early healthcare interventions, all of which can have a positive impact on their nutritional status.

The significance of medical facility births in reducing stunting highlights the importance of promoting skilled attendance at birth and improving maternal access to quality healthcare during pregnancy and childbirth. Encouraging expectant mothers to seek delivery services at healthcare facilities can potentially contribute to reducing the prevalence of childhood stunting by ensuring early access to essential health services and improved childcare practices.

5.2 Marginal effects of the determinants of stunting

According to this study, birth weight, place of residence, maternal height, birth interval, access to health services, maternal education, and social economic status have the highest marginal effects on stunting. Additionally, the maternal age and source of drinking water also had relatively high marginal effects on childhood stunting.

The analysis of this study found a significant and negative relationship between maternal education and childhood stunting. With the maternal education coefficient of -0.0343792, a percentage increase in maternal education will on average lower the chances of stunting by 3.4 percentage points. This finding highlights the crucial role of education in equipping mothers with knowledge and awareness about appropriate childcare practices and nutrition. Educated mothers are more likely to adopt recommended feeding practices, adhere to healthcare guidelines, and provide a nurturing environment for their children, all of which contribute to improved child health and reduced stunting risk. Therefore, it can be concluded from this study that the higher the education level, the lower the probability of stunting. This is supported by several other studies (Abuya, 2012; Assefa,2015; Haque, 2018; Akombi, 2017).

The study found that social economic status is inversely related to stunting. The coefficient of -0.034418 means that increasing the social economic status will lower the average probability of stunting by 3.5 percentage points. Higher social economic status provides families greater financial capacity to secure a balanced and nutritious diet for their children. Additionally, it allows better access to healthcare facilities, leading to timely interventions and improved child health outcomes. The social economic status has been associated with improvements in stunting status by studies in Nigeria and Ghana, as well as earlier studies conducted in Zambia (Akombi, 2017; Darteh, 2014; Kandala, 2001), all emphasizing the role of improved social economic status in mitigating the prevalence of stunting.

Regarding the place of residence, the study used urban as a reference for comparison. The Average Marginal Effects of the place of residence variable imply that children from households in rural areas are 5 percent less likely to experience childhood stunting than those in urban areas. This finding points to the potential negative influence of urban areas and the associated challenges on child nutrition. Urban environments often present greater disparities in income and access to basic services, which can impact dietary diversity and healthcare accessibility. Conversely, rural areas may benefit from greater reliance on farming activities, which can provide a more stable source of nutritious foods.

The average marginal effects on the source of drinking water was -0.0227381, indicating that the source of water has an inverse relationship with stunting. A percentage increase in improved water sources for households will reduce the probability of stunting by 2 percent. Access to clean and safe drinking water is crucial for maintaining optimal health and preventing waterborne diseases, which can negatively impact child growth and development. Ensuring improved water sources for households can therefore contribute to overall child health.

Maternal height and birth weight were also found to have a reverse relationship with stunting. According to the study findings, a percentage increase in maternal height and birthweight reduces the probability of stunting by 16 and 18 percentage points respectively. Not only does maternal height reflect genetics but it also reflects the mother's earlier nutritional status and other conditions which are in turn related to her schooling. Further, birth weight is also connected to the care of mothers during pregnancy. Nutritionally compromised women are at higher odds of giving birth to smaller babies who are in turn more susceptible to stunting (Dessie, 2019). These two variables emphasize the intergenerational link between mothers and their children.

Similarly, birth interval was also negatively associated with stunting. The birth interval affects the amount of care that children receive. According to the study results, a short birth interval increases stunting probability by 5 percent. A short birth interval may limit the amount of care that children receive, as mothers may be more focused on meeting the needs of multiple young children. Adequate spacing between births allows mothers to provide better care and attention to each child, positively impacting their nutritional status. Additionally, the study found that a percentage increase in maternal age lowers the probability of stunted growth by 2 percent. This finding echoes the study by Saxton, et al. (2016), highlighting the potential advantages of higher maternal age in promoting better child nutrition practices.

6 SUMMARY, CONCLUSIONS, LIMITATIONS, AND RECOMMENDATIONS

6.1 Conclusion

The rresearch shows that stunting is still a significant public health issue in Zambia among children under the age of five. The high frequency of stunting among children below five years observed, indicates that nutrition research is both relevant and crucial.

Further, this study confirms that stunting is the outcome of an intricate interaction of determinants. Wealth index, maternal education, maternal nutrition status, birthweight, place of birth, preceding birth interval, and sources of household water were found to have the highest marginal effects on childhood stunting.

As a result, initiatives and programs to reduce and eliminate childhood stunting must be designed to tackle multiple determinants simultaneously. According to the findings of this study, maternal care such as education, nutrition as well as programs that improve the social economic status of women must be given priority. Educating women is likely to improve the rates of employment among women which may lead to an improvement in their social economic status.

6.2 Strengths

The study had several strengths. Firstly, the data used for analysis was extracted from data sets that used internationally validated research instruments. Therefore, the variables found in the data sets are measured according to global standards. Secondly, the surveys' high response rate (>94%) indicates that research results can be generalized. Thirdly, this study provides a comparison of 1992, 1996, 2001, 2007, 2014, and 2018 data and investigates the trends in the determinants of childhood stunting in Zambia which were not analysed in previous studies. Such a comparison provides a benchmark for future research.

6.3 Limitations

The study also had some limitations. To begin, the analysis used cross-sectional data. Hence the research was unable to demonstrate a causal connection between the determinants and childhood stunting. Second, the study also does not represent seasonal variation of nutritional outcomes which may also provide important information for policy.

Thirdly, certain variables in the data sets depended on the respondent's ability to recall, making it vulnerable to recall bias.

Some characteristics were not consistently measured in all rounds of DHS data. For example, direct food security indicators such as the daily diet of households were missing in the 2018 ZDHS. While the mother's anemia status was missing in the 2014 ZDHS data sets. Therefore, the study did not include household dietary diversity score or mother's anemia status which are known predictors of stunting (Chowdhury et al., 2022; Semba 2008; Ricci, 1996). However, the study used household socio-economic status as an indicator for household food security and mother's height and BMI to explain mothers' nutrition and health status.

Additionally, the distinction between rural and urban has changed due to increasing urbanization. Therefore, some regions that were categorized as rural in earlier ZDHSs are categorized as urban in the latest ZDHSs, possibly resulting in inconsistencies in the calculation of urban-rural areas.

Finally, the study did not include qualitative data which would have helped to triangulate the findings of the quantitative analysis. To counter this, the study used an inclusive list of variables in the final analysis making sure that each dimension of the conceptual framework was represented by more than one indicator.

However, this research remains useful for developing public health policies and identification of the determinants of stunting. The results are able to assist the development and implementation of appropriate nutritional interventions aimed at child nutrition enhancement.

6.4 Recommendations

Interventions to end childhood stunting must be focused on improving the social economic status, especially in rural areas. These interventions must be combined with interventions to improve maternal education and the households' water sources and medical facilities. However, further research is needed to help explain why some variables that were considered important for children's nutritional status were found to be non-significant. For instance, fathers' education and women's empowerment.

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APPENDICES

Appendix 1.1: STATA code and commands to generate select variables

```
// stunting
sum hw70
ta hw70
replace hw70=. if hw70>600
sum hw70
gen haz= hw70/100
sum hw70 haz
gen stunting =0 if haz>=-2
replace stunting=1 if haz<-2
replace stunting=. if haz==.
label var stunting "childhood stunting"
label define stunting 1 "stunted" 0 "non-stunted"
label value stunting stunting
sort haz
*
*
// source of drinking water
numlabel, add
tab v113
gen dring_water = 1 if v113==11|v113==12|v113==13|v113==14|v113==21|v113==31 |v113==41
|v113==51 |v113==61 |v113==71
replace dring_water = 0 if v113==32|v113==42|v113==43|v113==96
tab dring_water
label define dring_water 1 "improved" 0 "unimproved", replace
label value dring_water dring_water
tab dring_water
tab v113 dring_water
*
// Maternal level of education
gen edu=0 if v106==0|v106==1
replace edu=1 if v106==2|v106==3
la var edu "education"
la de edu 0 "below secondary" 1 "secondary and above"
la val edu edu
*
//Paternal level of education
gen p_edu=0 if v701==0|v701==1
replace p_edu=1 if v701==2|v701==3
la var p_edu "education"
la de p_edu 0 "below secondary" 1 "secondary and above"
la val p_edu p_edu
*
// Place of blae
numlabel,add
gen bn_hsp=1 if m15==21|m15==22 | m15==23|m15==26| m15==31 |m15==32|m15==36
replace bn_hsp=0  if m15==11|m15==12 | m15==96
la var bn_hsp "born in health facilty"
la de bn_hsp 0 "not born in Health Facility" 1 "born in health facility"
la val bn_hsp bn_hsp
```

//Asset index

```
*-------------Principal components
pca v119 v120 v121 v122 v123 v124 v125 dring_water toilet2 ///
floor wall roof cooking
*
estat kmo
predict comp1
*hist comp1
rename comp1 asset_score
xtile asset_index= asset_score, nq(5)
la de asset_index 1 "Poorest" 2 "Poorer" 3 "Middle" 4 "Richer" 5 "Richest", replace
la val asset_index asset_index
la var asset_index "Asset index"
*
pca v119 v120 v121 v122 v123 v124 v125 v127 v128 v129 v161 v170
rotate
predict ad
```

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Comp7	Comp8
Electricity	0.3937	-0.137	0.069	-0.086	-0.0323	-0.1726	0.0047	0.1359
Radio	0.2011	0.5021	0.0503	-0.2854	0.0604	-0.4913	-0.1791	-0.3407
Television	0.3696	0.1185	0.0308	-0.0608	-0.0663	-0.2486	-0.05	-0.0109
Refrigerator	0.3659	-0.1215	0.2488	-0.1284	-0.0141	-0.077	-0.0298	0.1645
Bicycle	-0.033	0.6895	0.0013	-0.3105	0.2379	0.422	0.0565	0.2973
Motorcycle	0.0578	0.3757	0.237	0.8206	0.0496	-0.1974	0.1401	0.24
Car/ Truck	0.218	0.0302	0.5256	0.1376	-0.0464	0.5237	-0.0936	-0.599
Dring_water	0.2155	-0.1291	-0.3028	0.1801	0.6758	0.1757	-0.4653	0.0498
Toilet2	0.2536	-0.1021	-0.0872	-0.0522	0.4513	0.0007	0.7981	-0.1815
Floor	0.3683	-0.0232	-0.2632	0.0868	-0.1191	0.014	0.0166	-0.0627
Wall	0.2573	0.1328	-0.3387	0.0124	-0.4747	0.3325	0.1937	0.1456
Roof	0.3109	0.0774	-0.3608	0.1811	-0.1712	0.1239	-0.187	-0.1027
Cooking	0.2698	-0.1777	0.429	-0.163	0.0166	0.1134	-0.0822	0.5123

Appendix 1.2: Geographical association of stunting

Stunting		Adjusted Odds Ratio	p-value	Unadjusted Odds Ratio	p-value
Province	Western	Reference		Reference	
	Central	1.42 (1.18, 1.71)	0.000	0.85 (0.74, 0.97)	0.018
	Copperbelt	1.47 (1.21, 1.78)	0.000	1.01 (0.89, 1.15)	0.827
	Eastern	1.52 (1.27, 1.81)	0.000	1.24 (1.09, 1.41)	0.001
	Luapula	1.61 (1.41, 2.02)	0.000	0.87 (0.75, 0.99)	0.04
	Lusaka	1.71 (1.41, 2.08)	0.000	1.03 (0.90, 1.18)	0.662
	Muchinga	1.32 (1.11, 1.58)	0.002	1.42 (1.25, 1.61)	0.000
	Northern	1.86 (1.56, 2.21)	0.000	0.89 (0.78, 1.02)	0.092
	North western	1.38 (1.14, 1.66)	0.001	0.81 (0.71, 0.92)	0.001
	Southern	1.31 (1.10, 1.56)	0.003	0.78, (0.68, 0.89)	0.001