

**SPATIAL ANALYSIS OF STUNTING AND ITS ASSOCIATIONS
WITH KEY CHILD HEALTH AND NUTRITION DETERMINANTS AT
PROVINCIAL LEVEL IN ZIMBABWE**

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DECLARATION

I, Rufaro Musvaire, declare that this research report is my original work. It is submitted in partial fulfilment of the requirements for the Master of Public Health Degree at The University of the Western Cape, School of Public Health, Cape Town.

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ABSTRACT

Background: Childhood stunting is an issue of global public health concern, and its irreversible effects can have far-reaching consequences, well into adulthood. Despite various interventions and efforts, stunting in Zimbabwe remains high. Few studies have looked at the factors associated with stunting, by province, in Zimbabwe. The aim of the study was to contribute to the scientific evidence on this topic. This was done by describing stunting and its associations with maternal and child health, nutrition and sociodemographic determinants at provincial level. The second level was to map, visualise and describe stunting in relation to physical geography by province in Zimbabwe. **Methodology:** A secondary data analysis of the 2015 Zimbabwe Demographic Health Survey (ZDHS) was conducted. Data on 6,511 children under-five and their mothers were analysed. Using SPSS version 20, correlations between stunting and selected variables were identified. ArcGIS software version 10.8 was used to create maps to visualised stunting in relation to physical geography. **Results:** Overall, stunting in children was 27%. The lowest prevalence (18.8%) of stunted children was observed in Bulawayo, while the highest was in Matabeleland South (31.1%). The most occurring and significant correlations at provincial level were between stunting and the number of months of breastfeeding (positive, all p-values <0.001); stunting and mother's education level (positive, p-values from 0.000 - 0.005); and stunting and urban place of residence (positive, all p-values <0.05). Less observed but significant correlations included anaemia; the number of living children; mother's age and vitamin A supplementation. High-level mapping and visualisation suggested a potential link between physical geography and stunting. High temperatures, very low rainfall patterns, high altitude and low crop yield, seemed to be contributing factors. **Conclusion:** The study demonstrated factors associated with stunting by province. Understanding of stunting and its associations by geographic area can be used to design and target more context-specific interventions to address stunting in Zimbabwe.

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GLOSSARY OF TERMS AND DEFINITIONS

Anaemia	This condition occurs when there are low levels of healthy red blood cells or haemoglobin. Iron-deficiency anaemia is the most common type of anaemia. Women and children are high-risk populations.
Climate	The average weather in a given area over a longer period of time in terms of rainfall and temperature.
Climate change	Climate change is a long-term shift in global or regional climate patterns. Often, climate change refers specifically to the rise in global temperatures from the mid-20th century to present.
Complementary feeding	Complementary feeding is the introduction of solid foods into the diet of a baby who is drinking breast milk or formula milk. It typically begins from six months of age and continues to 24 months or beyond.
Data visualisation	The graphical representation of information and data by using visual elements like charts, graphs, and maps to see and understand trends, outliers and patterns in data.
Exclusive breastfeeding	This occurs when an infant receives only breast milk. No other liquids, including water, or solids are given. The World Health Organization recommends exclusive breastfeeding for the first six months of life.
Geographic information system mapping	A framework for gathering, managing, and analysing data by spatial location and organising layers of information into maps.
Physical geography	This refers to natural features on the earth's surface including landforms, drainage features, climate, soil and vegetation.
Spatial analysis	Any formal technique which studies entities using their topological, geometric or geographic properties.
Stunting	This is when a child has a low height for their age.

ABBREVIATIONS AND ACRONYMS

COHA	Cost of Hunger in Africa Study
DHS	Demographic and Health Survey
EC	European Commission
FNC	Food and Nutrition Council
FNSP	Food and Nutrition Security Policy
GDP	Gross Domestic Product
GIS	Geographic Information System
GNR	Global Nutrition Report
HAZ	Height for age Z-score
IFPRI	International Food Policy Research Institute
IYCF	Infant and young child feeding
MQSUN	Maximising Quality of Scaling Up Nutrition
SADC	Southern African Development Community
SD	Standard deviation
SDGs	Sustainable Development Goals
SHINE	Sanitation, Hygiene, Infant, Nutrition Efficacy
UNICEF	United Nations Children's Fund
VIF	Variance inflation factor
WASH	Water, sanitation and hygiene
WHA	World Health Assembly
WHO	World Health Organization
ZDHS	Zimbabwe Demographic and Health Survey

CHAPTER ONE

This chapter briefly introduces stunting and its effects globally and in Zimbabwe. Also presented in this chapter is the statement of the problem, the aim and objectives of the current study.

1. Introduction

Stunting is the most commonly used indicator of chronic malnutrition. It is assessed through the measure of height-for-age Z-score, according to specific cut-offs (World Health Organization - WHO, 2013). Therefore, a stunted child is one who has a low height in relation to their age. At the population level, the prevalence of stunting usually refers to the proportion of children aged 6-59 months who are classified with moderate and severe stunting (WHO, 2013). Chronic malnutrition, as indicated by stunting, is devastating to young children. It can result in impaired child brain development, lower intelligence quotient, weakened immune systems, and greater risk of diseases like diabetes and cancer later in life (Dewey and Begum, 2011). The effects of stunting not only last a child's lifetime; they can also be passed on from one generation to another, often perpetuating the poverty cycle (Black et al., 2008). Stunting is also the leading cause of child mortality worldwide, accounting for 35% of all child deaths (Black et al., 2008).

In Zimbabwe, stunting affects 27% of children under-five (Zimbabwe Demographic and Health Survey - ZDHS, 2015). With almost one in four children stunted, the overall evidence of successful implementation of stunting reduction interventions in Zimbabwe remains generally weak [Dandajena, 2013; European Commission (EC), 2015]. One of the identified gaps is that strategies to address stunting tend to be set at the national level with limited consideration to in-country variations (Maximising Quality of Scaling Up Nutrition - MQSUN, 2014; Reinhardt and Fanzo, 2014). This is almost a one size fits all approach that does not delve into the unique characteristics and attributes of stunting or other indicators of malnutrition by

geographic location, specifically at the sub-national level (Raiten and Bremer, 2020). The result is programmes that work in some areas but do not necessarily work, nor are they applicable across the board. There is limited appreciation of the differences in epidemiology, occurrence, and associations by location.

Furthermore, while spatially oriented approaches, including visualising and describing malnutrition in relation to unique characteristics of a location such as physical geography or environment are still seen as novelty methods. However, such outputs can help inform development of targeted and inclusive multi-sectoral interventions to combat stunting at the localised level (MQSUN, 2014). Undertaking such an exercise in Zimbabwe in complementarity with determining associations of stunting with child, maternal and contextual factors at provincial level, will also provide more contextual-based evidence about stunting by location. This evidence will be used to inform targeted resource allocation to meet the World Health Assembly (WHA) target of 40% reduction in the number of children under-five who are stunted by 2025 (WHO, 2014).

1.1. Problem statement

The prevalence of stunting in Zimbabwean children under the age of five years was 34% in 2010 (ZDHS, 2010) and reported as 27% in the 2015 ZDHS. Despite the reduction, the prevalence of 27% is high as per WHO classification. Moreover, based on the afore presented data, the annual average rate of stunting reduction is just under 1.5%. The latest projections anticipate that Zimbabwe will not meet the Zimbabwean government and WHA targets to reduce stunting by 40% by 2025 (Irigoyen, 2017). High rates of stunting continue to be observed in the country begging the need for further investigation of the contributory factors associated with stunting, and defining these at the subnational level. Furthermore, while the use of geographical mapping and visualisation of data to inform programming is gaining traction within the health sector, its use and application remain somewhat limited in the field

of nutrition (Kandala et al., 2011). With the exception of a few studies (Simler, 2006; Legg, 2008; Kandala et al., 2011; MQSUN, 2014; Bharti et al., 2019), not much work has been done around nutrition in this area. As a result, nutrition programme planning and resource allocation continue to be dominated and informed by aggregated results from national surveys without necessarily probing the unique and potentially contributory characteristics which could include physical geography, environmental or structural factors at the subnational level (Kiwanuka et al., 2008). Using the latest national Demographic and Health Survey data (DHS), analysis of stunting and its associations with determinants of child health and nutrition, coupled with mapping and visualisation of stunting in relation to physical geography, could highlight differences in drivers of stunting by province in Zimbabwe. The study will demonstrate the value of including mapping and visualisation as part of nutrition research. It will showcase its potential for use in better understanding localised factors, in this case physical geography, and how these may interplay with stunting or other forms of malnutrition. This will contribute to the evidence-base to inform implementation of the most appropriate nutrition-specific and nutrition-sensitive interventions based on location.

1.2. Study aim

The aim of the study is to describe stunting and its associations with determinants of child health and nutrition at the provincial level and to visualise stunting among children under five years of age in Zimbabwe in relation to physical geography. The outcomes of this research will be used to make more context-specific recommendations for the Zimbabwean government in terms of prioritising, scaling up, and targeting necessary resources to provinces to prevent or reduce stunting.

1.3. Objectives

1. To describe the prevalence of stunting and its associations with child health and nutrition determinants by province in Zimbabwe using ZDHS 2015.

2. To map, visualise and describe stunting in relation to physical geography by province.
3. To synthesise the findings of objectives 1 and 2 and present recommendations targeted to the affected provinces in Zimbabwe.



CHAPTER TWO

The primary focus of this chapter is on reviewing literature with regards to stunting. The chapter begins with an in-depth review of stunting in terms of its global distribution, significance and factors associated with stunting. This is followed by zooming into literature specific to stunting in Zimbabwe. Lastly, to feed into addressing the second objective of the study, a brief description of the provincial landscape of Zimbabwe, with a focus on physical geography is presented.

2. Literature Review

2.1. Definition of stunting

Stunting can be defined as low height for age (WHO, 2010). It is mainly due to poor nutrition, recurrent infections, or limited psychosocial stimulation (WHO, 2020). Tanjung, Prawitasari, and Sjarif (2020) stressed that stunting is a continuous process, which starts with the impairment of linear growth. Simply speaking, one may suspect stunting if a child does not grow in length or height in line with their potential (Tanjung, Prawitasari, and Sjarif, 2020). Stunting is determined by assessing a child's length (for children less than two years old) or height (for children age two years or older) and comparing the measurements with an acceptable set of standard values (De Onis and Branca, 2016). The most widely used definition of stunting was provided by WHO in 1995. According to this definition, stunting is "*having a height-for-age Z score (HAZ) $< -2SD$,*" where SD refers to the standard deviation (WHO Expert Committee, 1995). Despite the existence of international stunting standards, the problem of stunting often goes unrecognised because it may be difficult to visually recognise stunting (De Onis and Branca, 2016). De Groot et al. (2020) also confirmed that unlike starvation, stunting may not always be obvious, especially in its mild form. The lack of routine primary health care assessment in some communities also complicates the problem and prevents the introduction of timely interventions.

2.2. The global distribution of stunting in children

Stunting has unequal geographic distribution, as it disproportionately affects developing countries (Black et al., 2008). The stunting rates in different countries indicate the levels of inequality within the countries and, at the global level are a depiction of developed and less developed countries. The biggest population of stunted children under the age of five is in Asia, where at least 83.6 million children are stunted. Africa follows with 58.7 million stunted children (United Nations Children's Fund - UNICEF, 2019). The two continents contain the bulk of the least developed countries globally. In Latin America, the number of children with stunting reaches 5.1 million, while in North America, only 0.5 million children are stunted (UNICEF, 2019). As such, more than half of all stunted children under the age of five live in Asia, and more than one third live in Africa (UNICEF, 2019).

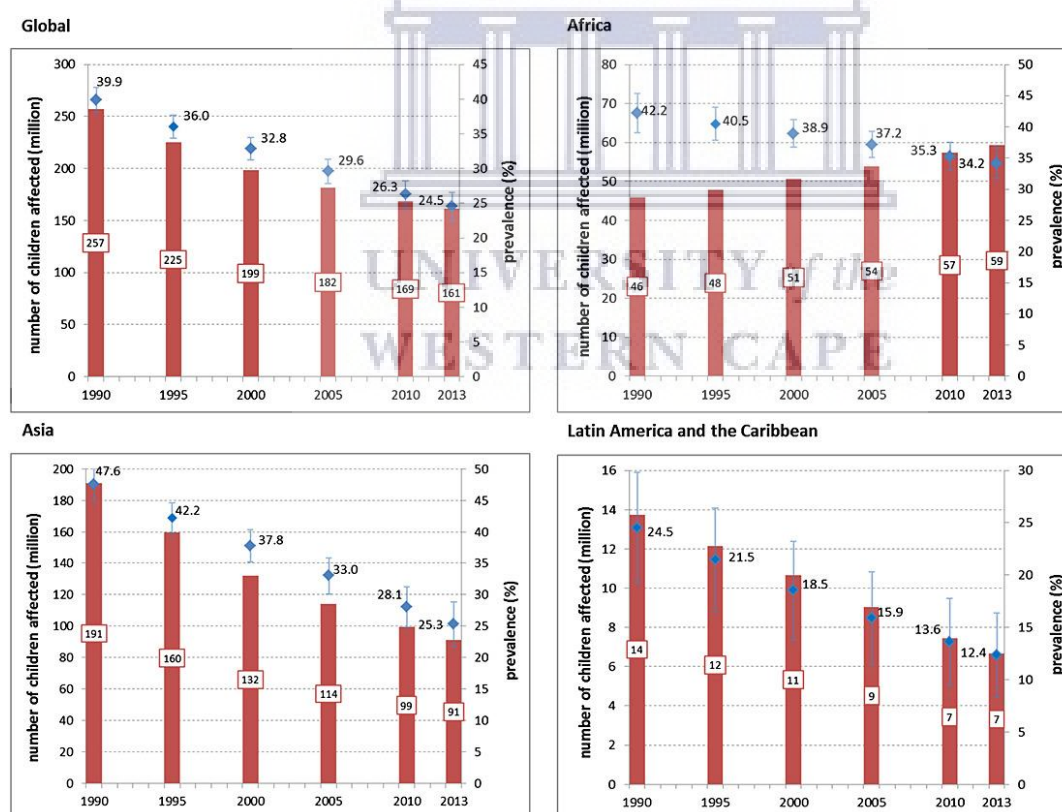


Figure 1: Global and regional comparison of stunting prevalence in children under-five (1990-2013)

Source: De Onis and Branca (2016)

As depicted in Figure 1, the percentage of all children under the age of five who were stunted was 26% in 2011, which was a decline from 40% in 1990. The highest prevalence was in Southern Asia and Africa. Given the slow reduction in Africa as compared to that of Asia, De Onis and Branca (2016) note that the situation is expected to escalate if there is no clear intervention because Africa has high fertility rates. The forecast (Figure 2) shows that by 2025, there will be an increase in the total number of stunted children in Africa, unlike in any other region.

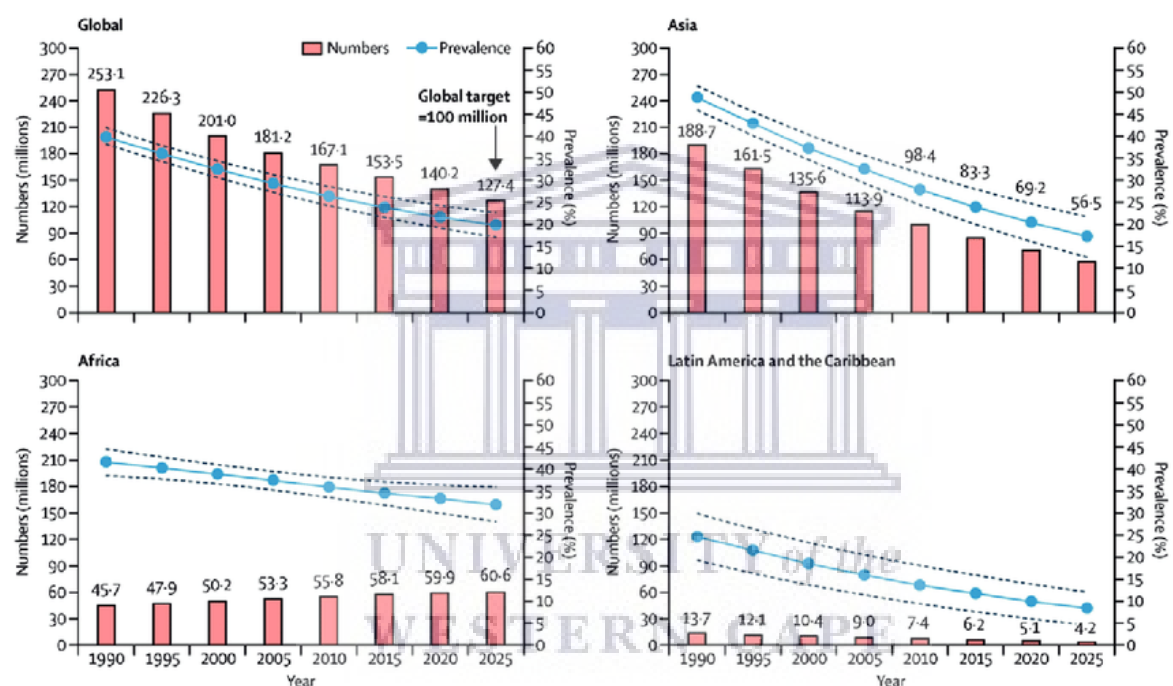


Figure 2: Forecasts of regional and global stunting prevalence

Source: Black et al. (2013)

The research by Buisman et al. (2019) suggests that progress in stunting reduction in Sub-Saharan African countries has been exceptionally uneven. The rates of stunting have been alarmingly high or have even risen in countries such as Sierra Leone and Mozambique (Buisman et al., 2019). Similar findings were reported by Asuman et al. (2019). These researchers added that the incidence of this public health problem is higher among children living in households with low socioeconomic status (Asuman et al., 2019). Data published in

2015 showed that 39% of stunted children in the world come from this region (Adebisi et al., 2019). Within Sub-Saharan Africa, Southern Africa is particularly challenged by high rates of childhood stunting. Stunting prevalence is shown to be above 30% in 11 out of 16 countries in the region [Southern Africa Development Community (SADC), 2019]. A prevalence of 30% is classified as very high by the WHO (de Onis et al., 2018). Reduction in stunting in countries in the region is occurring too slowly to meet the World Health Assembly (WHA) 2025 or Sustainable Development Goals (SDG) 2030 targets (International Food Policy Research Institute - IFPRI, 2016).

Like many countries in Sub-Saharan Africa, Zimbabwe has a high prevalence of stunting among children under the age of five. According to the latest ZDHS of 2015, stunting affects 27% of children under the age of five in the country. In an earlier regional meta-analysis conducted by Akombi et al. (2017), the prevalence of stunting in Zimbabwe in 2011 was 32%.

2.3. Why is stunting an issue of global public health concern?

Childhood stunting is one of the most significant impediments to human development (Global Nutrition Report - GNR, 2018). It is a form of chronic malnutrition, which develops over a long period of time (WHO, 2013). Stunting typically develops during the first 1,000 days which is the time spanning roughly between conception and a child's second birthday (Black et al., 2008). It is a vital condition that calls for intervention by the fact that it is irreversible, and so are its impacts (Dewey and Begum, 2011). Moreover, evidence points to stunting being a key cause or contributor for underdevelopment in developing regions such as Southern Asia and Sub-Saharan Africa where approximately 64 million and 47 million children respectively are stunted (WHO, 2018). It is widely recognised that stunting early in life has severe adverse consequences in terms of health, social development, and economic opportunities (WHO, 2020).

While stunting manifests as a child under the age of five years being too short for their age (Dewey and Begum, 2011), the less visible impacts of stunting are far more devastating (Bhutta et al., 2008). For example, stunted children are more likely to become ill and face a higher risk of dying (Black et al., 2008). Children suffering from stunting may never attain their full possible height, and their brains may never develop to their full cognitive potential (Black et al., 2013). Furthermore, they are more likely to drop out of school and grow up to be less productive citizens with lower earning potential (Victora et al., 2008). As adults, stunted children are at increased risk of nutrition-related chronic diseases, such as diabetes, hypertension, and heart disease (Dewey and Begum, 2011; DeBoer et al., 2012). Collectively, this translates into reduced economic productivity in developing countries and billions of dollars in lost revenue as well as a high burden on national health systems (Victora et al., 2008; Alderman, 2010). The community is hampered by the fact that stunting not only affects the physical but also the neurocognitive development of children throughout their lives hence affecting the society at large. In fact, research shows that reducing the prevalence of stunting can increase gross domestic product (GDP) by up to 11% a year in Africa (Cost of Hunger in Africa Study - COHA, 2013).

Stunting may also be accompanied by microcephaly, which is defined as *“head circumference two or more standard deviations below the age-adjusted mean”* (Musisi and Jacobson, 2015). It has been found that stunting also results in smaller brain volume and central nervous system abnormalities (Musisi and Jacobson, 2015). A study by Olusanya (2012) revealed that microcephalic infants tend to be significantly underweight and stunted. Regardless of their status at birth, microcephalic infants at six to eight weeks are likely to be malnourished. These findings demonstrate that head circumference may serve as a complementary screening tool for the early diagnosis of malnourished infants (Olusanya, 2012). As stated by Guerrant et al. (2013), a child’s height at their second birthday is the best predictor of cognitive development.

This statement can be supported by numerous studies showing a significant association between stunting and limited cognitive development. For example, a study by Woldehanna, Berhman and Araya (2017) examined the effect of early childhood stunting on cognitive achievement and found that this problem is significantly negatively associated with cognitive performance. Such results were obtained after controlling for many confounding variables such as the duration of breastfeeding, the history of diseases, as well as gender and household income (Woldehanna Woldehanna, Berhman and Araya , 2017). Asiki et al. (2019) also found that stunting is associated with fewer schooling years in low-income settings. Given the aforementioned evidence, it is not surprising that stunting leads to poor cognition and educational performance.

McGovern et al. (2017) found that a one centimetre increase in stature is associated with a 4% increase in wages for men and a 6% increase in wages for women. Hoddinott et al. (2013) also confirmed the association between stunting and adult wages, thus showing the convincing economic rationale for stunting reduction. Finally, Chakravarty et al. (2019) stressed that human capital development starts from early childhood, which means that stunting early in life should be addressed to promote the development of human capital and break the cycle of poverty.

Children who are stunted are at an increased risk for recurrent infections and are more likely to die from pneumonia, diarrhoea, and measles (Oot et al., 2016). These infections can impair the functionality of the body through a reduction in appetite, reduced functioning of intestinal absorption, increase in catabolism, and re-direction of nutrients away from growth and towards immune response (De Onis and Branca, 2016). These circumstances not only impact the child through the deterioration of health but also make the child more susceptible to even more chronic nutrition-related diseases such as anaemia and other deficiency diseases. To this end, stunting has also been associated with deficiencies in other nutrients in children (Caulfield et

al., 2006; Rahman et al., 2019). Given the often already weak immunity of such a child, stunting, compounded with other health conditions, proves to be of vital concern and perpetuates the ability of stunting to result in death.

Transgenerational health effects of stunting have also been reported in the literature. Musisi and Jacobson (2015) argued that stunted girls grow up to become short women with disproportionately smaller birth canals. Such women have an increased risk of obstructed labor, so they may be encouraged to eat less so that they do not gain too much weight during pregnancy. In this way, maternal malnutrition begins to affect the fetus and can result in child stunting which in effect leads to the intergenerational cycle of malnutrition (Musisi and Jacobson, 2015).

As a result of its far-reaching consequences, stunting prevalence is a key factor used as the basis of nutrition programming decisions. The prevalence of stunting gives an indication of the likelihood that a child under the age of five in a given population is not receiving adequate nutrition to reach optimal growth and development (Prendergast and Humphrey, 2014). Stunting is also the leading cause for child mortality worldwide, accounting for 35% of all children deaths (Black et al., 2008).

2.4. The determinants of stunting

Malnutrition occupies a central place in Stewart et al. (2013)'s conceptual framework of childhood stunting, which they developed as part of WHO's initiative to combat this global health problem. The scholars argued that poor quality foods are a serious problem due to several factors including low micronutrient quality, low dietary diversity, and low energy content. They criticised inadequate feeding practices such as infrequent or insufficient feeding, the lack of high-nutrient food during illnesses, and non-responsive feeding. It is believed that socioeconomic conditions and national and global differences are the main factors affecting food security, childcare, and household environment, all of which, in turn, further affect disease

occurrence, dietary intake, and children's nutritional status (Zhihui et al., 2020). Indeed, it is increasingly recognised that stunting may be caused by many other reasons besides malnutrition.

2.4.1 Socio-demographic factors

Keino et al. (2014) state that, among other factors, stunting is also influenced by several socio-demographic elements including the setting (rural/urban), gender, mother's education and occupation, household income, and sanitation. A similar broader perspective on stunting was used by Wicaksono and Harsanti (2020), who explored determinants of stunting in Indonesia. The researchers used a large sample of 76,165 children under five years. Factors associated with stunting included gender (boys were found to be more at risk than girls), living in slums, and large family size. Protective factors included having educated parents, living in an urban area, and living in a province with a higher GDP (Wicaksono and Harsanti, 2020). A cross-sectional study in Ethiopia with a sample of 410 children aged 6-59 months found that being female, belonging to the age group of 25-59 months, and being underweight at birth were positively associated with stunting (Abeway et al., 2018). Other associated factors identified by Beal et al. (2018) included poor access to health care and living in rural areas.

Maradzika et al. (2016) conducted research in Harare using a sample of 342 mother-child pairs. It was found that lack of maternal education was the major risk factor for stunting, and this was aggravated by parental unemployment, birth weight, illness and infections, area of residence, feeding practices, and dietary diversity (Maradzika et al., 2016). A more recent study by Ncube et al. (2020) conducted in Insiza District of Matabeleland South province revealed that stunting was associated with household headship, parents' marital status, income, family size, parental education, and religion. Yaya et al. (2020) found stunting to be more prevalent in Zimbabwean boys compared to girls (29.6% versus 24%, respectively). Moreover, stunting affected rural residents more than urban ones (28.5% versus 22.1%) (Yaya et al., 2020).

2.4.2 Factors related to child dietary and nutrient intake

In a study by Beal et al. (2018), which included a comprehensive review of evidence on factors causing stunting in Indonesia, revealed that stunting is associated with non-exclusive breastfeeding for the first six months. A cross-sectional study by Martin (2001) on the impact of breastfeeding on growth indicated that the length of breastfeeding in Britain was associated with childhood stature, which continued into adulthood. The study further showed a significant difference in the growth of children between those who were breastfed compared to those who were given formula milk. At seven years of age, the two sets of children differed in height (with those that breastfed being taller). In this study, breastfeeding was then noted to have been related to the growth tempo of the child and had an impact on child growth hormones. According to research by Muldiasman et al. (2018), early initiation of breastfeeding can prevent stunting in children aged 6 to 59 months.

A study in Malawi by Kuchenbecker et al. (2014) found that compared to non-exclusively breastfed children, those that were exclusively breastfed for the first six months of life were taller, weighed more, and bore less risk of being stunted. The study found that the change from breast milk to other fluids at the age of four months was closely associated with the increasing risk of exposure to infections and prolonged diarrhoea that can cause stunting (Kuchenbecker et al., 2014). A study by Yaya et al. (2020) noted the role of age and perception on the impact of initiation to breastfeeding and concluded that the younger mothers 15-19 years were faster at initiating non-exclusive breastfeeding practices compared to their counterparts who were aged 25-34 years. The authors concluded that children born of younger mothers were more prone to stunting, not only due to high chances of underweight but also the reduced knowledge and willingness in practicing certain maternal practices, such as breastfeeding, that can prevent stunting in children (Yaya et al., 2020). An investigation by Martin (2001) on stunting rates in African countries including Togo, Zimbabwe, Uganda, and Nigeria, found that these were

linked with the average duration of breastfeeding among mothers. However, a study in Pakistan (Syeda et al., 2020), found that prolonged breastfeeding could well contribute to stunting. In fact, the authors emphasised that efficient breastfeeding should not go beyond the age of two. In the results, it was posited that the children who were breastfed for three years developed severe stunting and were at higher risk for stunting in comparison to their peers aged two years (Syeda, et al., 2020). In other words, too much of a good thing may have unintended negative consequences. Certainly, this research shows the need to educate mothers and other caregivers on the role of breastfeeding but should caution them on the danger of prolonged breastfeeding beyond the age of two years, with this having a possibility to cause severe stunting. This may be more applicable in certain settings where over-reliance on breast milk could result in deprivation of energy and nutrients from a more diversified dietary intake.

In terms of micronutrients, Ssentongo et al. (2020) set out to identify the role of vitamin A in the control of stunting in Uganda. The cross-sectional study findings showed that vitamin A was able to control the secretion of the growth and thyroid-stimulating hormones which in turn improved height gains in children (Ssentongo et al., 2020). However, the investigators noted that while the findings could not be generalised and were rather population-specific, interventions that involve the use of Vitamin A in Sub-Saharan Africa have shown possible improvements to stunting. According to Rossa (2016), the main causes of stunting in Zimbabwe include unbalanced diets among children in their first two years of life and poor nutrition in pregnant women and breastfeeding mothers. Specifically, for Zimbabwe, investigations by UNICEF have found that stunted children were more deficient in some nutrients (Rossa, 2016). The first 1,000 days of a Zimbabwean child have been noted to be typically nutritionally deficient in iron, calcium, vitamin A, and high-quality protein (Kairiza et al, 2020). A research study by Kairiza et al. (2020) also found the prevalence of iron deficiency anaemia to be very high (81%) in stunted children in Zimbabwe.

Notably, a study by Prendergast et al. (2019) conducted in Zimbabwe showed that improvements in child feeding could lead to improvements in linear growth among HIV-infected children. Whereas, water, sanitation, and hygiene (WASH) interventions had no such effect. Another study that needs to be mentioned in this relation is the one by Kairiza et al. (2020) on the effect of food fortification on stunting in Zimbabwe. The sample used in this study included 25,297 households with at least one child under the age of five. It was found that food fortification reduces stunting and that women who adopt this practice are more likely to improve their children's growth status (Kairiza et al., 2020). Maradzika et al. (2016) and Ncube et al. (2020) also found associations between stunting and child feeding practices, including the number of meals a day and the dietary diversity of Zimbabwean mothers.

2.4.3 Physiological and disease-related factors

Repeated diarrhoeal episodes and infection may contribute to or drive stunting among children. As explained by Guerrant et al. (2013), enteric infections have an adverse effect on gut health and cause diarrhoea. Berhe et al. (2019) confirmed that prolonged diarrhoea may be one of many causes of stunting in children aged 6-24 months. The problem is complicated by the fact that children under the age of five are disproportionately exposed to infections associated with taking non-breast milk, and more tendency to ingest contaminated materials. Infected children, in turn, have a diminishing appetite, cannot absorb nutrients effectively, and lose nutrients, all of which ultimately leads to stunting (Berhe et al., 2019). Enteric infections resulting in severe diarrhoea can cause high mortality, and they are especially prevalent in developing areas (Guerrant et al., 2013). As supported by research, children that are abruptly or prematurely introduced to other fluids and foods before the age of six months are highly prone to exposure to contaminants that can cause an increase in rates of infections as compared to children that exclusively breastfed (Kuchenbecker et al., 2014; De Onis and Branca, 2016; Beal et al. 2018; Chidziwisano et al., 2019). Unhygienic conditions align with increased risk for diarrhoea and

associated illness and as such, go beyond causing stunting as found by Berhe et al. (2019) and, also explained by Guerrant et al. (2013). This then sets up an environment where a vicious cycle of malnutrition and infection perpetuates in young children, as illustrated by Rodriguez-Morales et al. (2016) in Figure 3.

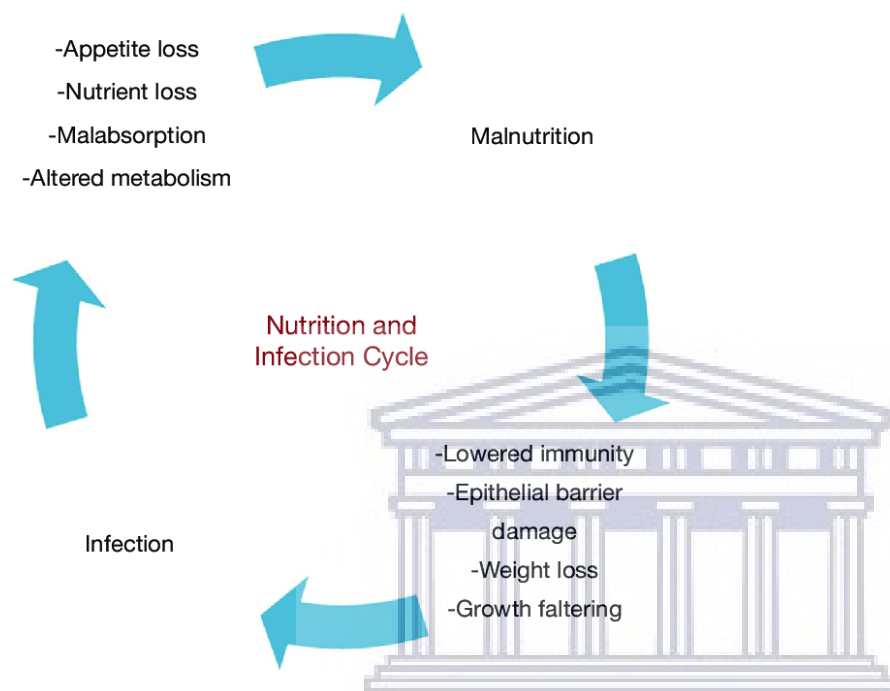


Figure 3: Nutrition and infection cycle

Source: Rodriguez-Morales et al., 2016

According to Reiten and Bremer (2020), physiological factors contributing to stunting may include maternal-fetal interactions causing intrauterine growth retardation, as well as maternal and pediatric infections. Tanjung, Prawitasari, and Sjarif (2020), in turn, mentioned genetic and endocrine disorders as causes of stunting. Some researchers went further and examined the problem of gut health and its association with stunting. For instance, Kumar et al. (2018) explored the relationship between altered gut microbiota and child malnutrition. The scholars compared gut microbiota collected from children from three countries and found impaired metabolite production and reduced number of essential amino acids in children from developing countries (Kumar et al., 2018). These findings were partially confirmed in a study

by Vonaesch et al. (2018). However, these studies perceived altered gut microbiota as a consequence rather than a cause of malnutrition. Furthermore, Dinh et al. (2016) argued that moderate or severe malnutrition is associated with continued immaturity of the gut microbiota, and this association warrants further research as it may show the path to treating stunting in malnourished children. In a study with a sample of 202 stunted infants, it was found that stunting begins in utero and is caused by low maternal insulin-like growth factor levels at birth (Prendergast and Humphrey, 2014). Moreover, chronic inflammation during the first months of life was also found to cause developmental impairment (Prendergast and Humphrey, 2014).

Infection with HIV was found to increase the incidence of stunting among Zimbabwean children. A study by Omoni et al. (2017) involving an impressive sample of 14,110 children found that HIV infection in utero or intrapartum was associated with very high rates of stunting during the first two years of life. These findings support the position of WHO (2020), which maintains that infections are closely connected to developmental failures early in life.

By learning the potential underlying disease and physiological factors, healthcare providers could develop effective interventions aimed at addressing them.

2.4.4 Knowledge and behavioural factors

Health-seeking behaviour has been linked to stunting. Lack of antenatal care visits during pregnancy, followed by irregular child growth monitoring checks have been found to cause stunting (Abeway et al., 2018). Nshimiyiryo et al. (2019) reported that a mother's history of not taking deworming medicine during pregnancy may also drive a child's stunting, while Gebre et al. (2019) found that, immunisation status was also a determinant of stunting. Studies in the rural areas of Zimbabwe bring to the fore the extent to which behaviours, particularly around infant and young child feeding (IYCF) and child care, can drive stunting. In their study in Gwanda District of Matabeleland South, Mundagowa et al. (2019) found that 89% of the mothers had enough knowledge about exclusive breastfeeding, with 84% of them having a

positive attitude towards the practice but only 36% of them breastfed their children. Such findings underpin the need for a better understanding of behaviour-related factors and how these contribute to stunting in different settings. In their research, Kairiza et al. (2020) also highlighted behaviour as a key factor. When notified about the importance of fortified supplements, mothers of children with micronutrient deficiencies were receptive and adopted fortified supplements. This indicated that on the one hand, there is an issue of availability and access to nutrient-rich foods, but on the other, lack of knowledge about good nutrition strongly influences behaviour and subsequently nutritional outcomes.

2.4.5 Factors related to physical geography

Spatial analysis of stunting in districts of India revealed a positive association between extreme temperature and stunting (Bharti, Dhillon and Narzay, 2019). As high as 40% of children living in districts with very high temperatures ($>40^{\circ}\text{C}$) were stunted. The same study also found stunting to be negatively associated with crop production. In other words, stunting increased as crop production decreased (Bharti, Dhillon and Narzay, 2019). In their longitudinal study covering 43 administrative zones of Ethiopia, Hagos et al. (2014) also observed a positive association between stunting and temperature as well as stunting and rainfall. In terms of precipitation patterns, both excessive rainfall and very low rainfall have been found to be associated with worsening nutritional outcomes, including stunting, in children (Cooper et al., 2019). Space-time modelling of cross-sectional studies from 2007 to 2010 in Somalia found rainfall and vegetation cover to be strong predictors of stunting in different regions (Kinyoki et al., 2016).

High altitude has also been associated with increased risk of stunting in a few studies. A study in Tibet revealed that children living at an altitude greater than or equal to 3,500 metres above sea level carried up to six times greater risk of being stunted (Dang, Yan and Yamamoto, 2008). Research in Ethiopia also found that the odds of stunting were up to 1.4 times higher among

children living at an altitude of 2,500 metres above sea level in comparison to those living below 1,000 metres (Mohammed et al., 2020). Research has established that the link between altitude and stunting originates during pregnancy (Baye, Hirvonen and Wu, 2020). Pregnant women in high altitude settings with lower oxygen supply are at higher risk of fetal growth restriction, which subsequently increases the risk of stunting in early childhood (Baye, Hirvonen and Wu, 2020).

As a critical emerging global issue, climate change may also exacerbate the effect of environmental conditions, making some regions and countries even more vulnerable to stunting. Cooper et al. (2019) found that arid low-income countries, which are often affected by droughts, have a high prevalence of stunting. As such, the role of physical geography in the prevention of stunting comes to the fore, particularly given that for many countries, agricultural activities provide the primary source of access to food to prevent chronic malnutrition.

2.4.6 Environmental factors

While these have not been covered extensively within the scope of the current study, Reiten and Bremer (2020) state that environmental factors such as the physical environment might also affect children's growth. Sinharoy, Clasen, and Martorell (2020), in turn, noted that while poor WASH conditions are indeed a problem, air quality may also be an important factor to consider but stressed that more research is needed.

From the literature, factors determining stunting do indeed emerge at the earliest stage of a child's development and may not always be controlled. As noted by Zhihui et al. (2020), many studies have attempted to assess the association of multiple factors with child development failures in India, Rwanda, Bhutan, Nigeria, and other countries. However, the results are not necessarily comparable across countries because there are unique sets of factors that affect stunting in each country. Therefore, country-level research is strongly recommended. Although these findings may not all be generalised to all countries, the review of the literature does

provide a clear picture of the variety of individual, community, and social factors and impacts that need to be considered in stunting prevention programmes.

2.5. Interventions to address stunting in Zimbabwe

There are several efforts underway to reduce stunting in Zimbabwe. However, one concern raised by the UNICEF studies in Zimbabwe is that the interventions in the nutritional dimension are limited in terms of coordination and resourcing (Food and Nutrition Council - FNC and Kembo, 2018). There is need for improvements in the nature of interventions through better identification of the causes or drivers of stunting in different parts of the country so as to target them accordingly.

The 2014-2018 Zimbabwe National Nutrition Strategy mentions different factors that continue to weaken the response and impact of the interventions. These include inadequate knowledge of practitioners regarding child and maternal nutrition as well as inadequate WASH practices and insufficient interventions aimed at teenage mothers and pregnant adolescents (FNC and Kembo, 2018). UNICEF (2020) notes that only 4% of caregivers in Zimbabwe have adequate knowledge on the right amounts and types of diet required for children in their first 1,000 days of life. Interestingly however, Sanitation Hygiene Infant Nutrition Efficacy (SHINE) trials which ran from 2012 to 2017 in Zimbabwe (Smith et al., 2015) and assessed the efficacy of WASH and improved IYCF interventions on nutrition concluded that these two interventions were inefficient in reducing stunting and anaemia, even when combined, though IYCF was found to be slightly better on its own.

A number of national policies and programmes in Zimbabwe either directly or indirectly aim to combat stunting. Noteworthy among these are the launch of the National Food Fortification Strategy in 2015. This made it compulsory for major local food manufacturers to fortify processed staple foods in the country with a target of reducing stunting and micronutrient deficiencies among children (Kairiza et al., 2020). There is also the National Food and

Nutrition Security Policy (FNSP) of 2013 which aims to “*ensure adequate food and nutrition security for all people at all times in Zimbabwe, particularly amongst the most vulnerable and in line with our cultural norms and values and the concept of rebuilding and maintaining family dignity*”. The policy is a government policy to overcome nutritional issues in the country. However, Irigoyen (2017) notes that the government-led FNSP and other interventions to address child malnutrition are fraught with several constraints as summarised in Figure 4.

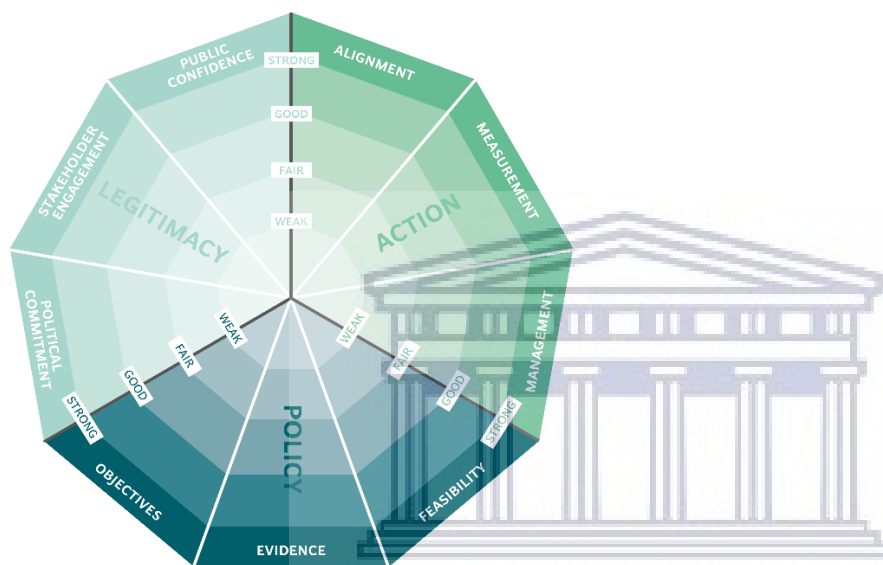


Figure 4: Quality of National Food and Nutrition Policy and related interventions in Zimbabwe

Source: Irigoyen (2017)

Despite very good stakeholder commitment and political effort, the evidence and objectives of the FNSP have been rated fair, and their feasibility and actions are very weak (Irigoyen, 2017). The policy is not able to present measurable components and there seem to be concerns around confidence in the government.

The above findings shed some light on the causes of stunting in Zimbabwe, as well as the existing interventions to address it. In 2017, the EC recommended expanding the existing knowledge on the causes of stunting in Zimbabwe to inform effective evidence-based

interventions. More research is indeed needed to address the gaps in knowledge and help policymakers introduce country- and region-specific programmes aimed at combatting malnutrition and stunting. It also is important to gain a better appreciation for the potential contribution that physical geography can have in the area of stunting. This includes variables such as altitude, rainfall and temperature, among others. Reinhardt and Fanzo (2014) highlight that stunting interventions have largely neglected biophysical factors and that unless these factors are also taken into consideration, particularly with the emerging issues around climate change, responses to stunting may not be comprehensive. It is against this backdrop that the current study seeks to undertake mapping and visualisation of geographical factors in characterising stunting by location, and to dig more into maternal, child and contextual associations of stunting specifically at provincial level.

The literature reveals that stunting is associated with different factors. These include factors such as age, gender, household income, environmental issues, among others, which have been posited to impact the nature of nutrition and hence stunting in unique and indirect ways (Wicaksono and Harsanti, 2020; Cooper et al., 2019). It is therefore clear that determining the causal relationships requires a comprehensive approach and an understanding of the complex interactions between child development and these factors (Boah et al., 2019). As indicated by Reiten and Bremer (2020) and partially supported by Scheffler et al. (2020) as well as Keino et al. (2014), nutritional interventions alone may not be enough. Scholars call for embracing a more holistic ecological approach to the problem of stunting. This approach considers a myriad of other factors contributing to this condition (Reiten and Bremer, 2020). According to Rossa (2016), UNICEF's Regional Director of Southern Asia noted that there is a need for large scale intervention programmes directed towards women and children in a bid to prevent stunting. However, this professional also notes that the strength of these interventions is dependent on the certainty of the evidence used for these interventions. Furthermore, these interventions are

meant to focus on the most vulnerable children and mothers in different regions. Hence, the importance of determining the associations of stunting by location can hardly be overestimated.



CHAPTER THREE

This chapter presents the methodology of the current study in terms of study design, study setting and study population. A description of the data collection and data cleaning processes is provided, followed by an explanation of how the data was analysed. The chapter ends by outlining the ethical considerations for the study.

3. Methodology

3.1. Study design

The current study is a retrospective quantitative descriptive study that utilised secondary data from the 2015 ZDHS. The ZDHS is a single cross-sectional nationally representative survey that was conducted over six months from July to December of 2015.

3.2. Study setting

The study is set in Zimbabwe, a Sub-Saharan African country which is divided into ten provinces: Manicaland, Mashonaland Central, Mashonaland East, Mashonaland West, Matabeleland North, Matabeleland South, Midlands, Masvingo, Harare, and Bulawayo as presented in Figure 5.

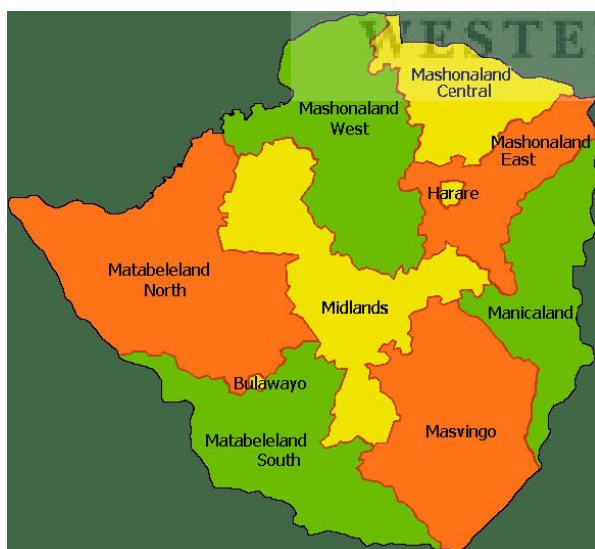


Figure 5: Provincial map of Zimbabwe

Source: Build Zimbabwe Alliance <https://buildzimbabwe.org/business-recovery-plans/>

3.3. Study population

In the 2015 ZDHS, a total of 11,196 households were interviewed, and anthropometric measurements for 6,511 children aged 0 to 59 months were included in the study. All households with children of the aforementioned age group, with anthropometric measurements, specifically height data available, were included in the secondary study. The ZDHS yielded an overall 99% household response rate; 96% women response rate and 92% male response rate.

3.4. Data Collection

Permission to access the 2015 ZDHS data, which is the most recent DHS conducted in Zimbabwe, was sought and granted from The Demographics and Health Surveys Program (<http://dhsprogram.com>).

The ZDHS administered a women's questionnaire to collect information from women between the ages of 15 and 49 years on various topics including background characteristic, breastfeeding and infant and feeding practices, vaccinations and childhood illnesses among others. Height measurements were carried out for all children aged 0-59 months in all households. As per standard global practice, the recumbent length was measured for children under 24 months of age while standing height was measured for older children. Height-for-age was calculated using the anthropometric measurements that were taken in the study. For the weight measurements, SECA digital electronic scales were used, while ShorrBoards® were used for height and length in the survey. They were expressed in terms of deviation from the median (Z-scores) for individual children, using the WHO growth standards published in 2006.

For the current secondary study, the files with the relevant datasets, in this case the ones containing, health, nutrition and socio-demographic information about women and children were extracted from the DHS electronic system onto SPSS as follows:

Stunting: interpreted as height for age Z-score which is less than -2, in line with WHO new growth standards.

The following maternal and child factors were considered in this study for investigating association with stunting:

Health and nutrition-related factors: months breastfed, anaemia, vitamin A₁ supplementation, vaccination status and possession of a health card.

Socio-demographic factors: mother's age, mother's highest level of education, number of living children, mother's employment status and place of residence (urban/rural).

The physical geography mapping and visualisation design was informed by a similar study (Legg, 2008). Legg (2008) used gridded data on topography and climate, including rainfall and temperature, in West and Central Africa to establish how ecological zones and climate related to child nutritional status in the region. Simler (2006) used publicly available geo-referenced data including information on climatic conditions (mean annual rainfall and mean temperature) and integrated the geo-referenced data with the tabular data from the DHS to map nutrition by region and district in Tanzania.

For this study, Landsat satellite imagery on rainfall, temperature, altitude and vegetation type for Zimbabwe was extracted from Earth On Demand (<https://earthondemand.astraea.earth/>). Earth On Demand is a global repository of imagery that is publically available for mapping and visual analysis to meet different information needs.

3.4.1. Mapping and visualisation by physical geography

The stunting data was extracted onto Excel and from there converted into shapefiles to enable mapping on ArcGIS software (see Appendix 1 and Appendix 2 for the Excel and ArcGIS data collection tools, respectively). ArcGIS is an information system for working with maps and geographic information. It is maintained by ESRI, a California-based international supplier of geographic system software which was founded in 1969. ArcGIS is used for creating and using maps, compiling geographic data, analysing mapped information, sharing and discovering

geographic information, using maps and geographic information in a range of applications, and managing geographic information in a database. The specific version of ArcGIS used for the study was ArcGIS Desktop Advanced Version 10.8 (2019.2 Windows License).

ArcGIS was used to illustrate, through geographical information system (GIS) mapping, the distribution pattern of stunting across provinces in Zimbabwe in relation to physical geography namely, altitude, climate (rainfall and temperature) and vegetation type. This information was then used to describe the landscape across the provinces and make some inferences on how physical geography could also be a factor with regards to the distribution of stunting.

3.5. Data Cleaning

Data management involved checking the dataset containing responses on health, nutrition and socio-demographic characteristics of children and their mothers for extreme and inconsistent values. Outliers and flagged cases were removed for all the variables. In some instances, for example, vitamin A₁ where there were various response categories, these were merged to be categorical (dichotomous) therefore only have yes/no response.

3.6. Data Analysis

Because of the categorical nature of the data, Pearson's correlation was to evaluate if any significant associations existed between these selected data (i.e. the categories of the maternal and child health/ nutrition/ socio-demographic factors). Spearman correlations on the other hand was used to evaluate the relationships involving the ordinal variables (i.e. stunting and the associated maternal and child health/nutrition/socio-demographic factors). The aforementioned analyses were done for each variable by province to a total of ten provinces across Zimbabwe. The test of statistical significance used was the p-value <0.05 . To identify which of the variables had the strongest association with stunting, a regression analysis was performed. The statistical package used for the analyses was the IBM Statistical Package for Social Science (SPSS) software, version 20.

3.7. Validity

Validity in research indicates the extent to which a study measures what it is meant to measure (Creswell, 2014). In the current study, validity suggests the degree to which the association between stunting and health, nutrition and socio-demographic factors, as well as mapping and visualisation of stunting in relation to physical geography, are effectively measured using appropriate tools. For the analysis of associations, the nutritional status related data was described in line with global thresholds/cut-off points used to categorise the respective indicators, for example, the WHO classification of stunting prevalence by low, medium, high and very high. The validity of the mapping and visualisation exercise was improved by extracting satellite imagery for Zimbabwe not more than five years old. Given that stunting is a chronic indicator that evolves over an extended period, and characteristically does not fluctuate, the use of physical geography imagery not more than five years old was an appropriate point of comparison.

3.8. Reliability

Reliability indicates the consistency of the results of the study (Creswell, 2014). For the descriptive analysis, validity was increased by only investigating the strength of associations for variables that had complete data sets or not more than 10% in missing data. For the mapping and visualisation exercise, the primary researcher collected and mapped the data, and an independent person (a geographical information system specialist) checked the accuracy of the information. This was done by mapping the same data set on a smaller scale and verifying this against the maps produced by the primary researcher. The study was fully electronically based and managed online with desktop backup, therefore did not involve any manual manipulation of the data.

3.9. Generalisability of the study results

All provinces of Zimbabwe were included in the study. As such, the study results are generalisable to the entire country of Zimbabwe. However, it is important to note that there will be different characteristics by province observed, as per the objectives of the study. While the current study undertook a provincial analysis of the association of stunting with determinants identified specifically for the Zimbabwe context as well as mapping based on the physical geography of Zimbabwe. Therefore, the principles, particularly in terms of the approach and methodology to inform better nutrition programming by geographic location, are of relevance and interest to different countries and settings with similar characteristics as Zimbabwe.

3.10. Ethical Considerations

The current study relied solely on the 2015 ZDHS database, the permission of which was granted by the International DHS and the ZDHS Programme (see Appendix 3), who are the data owners. All ZDHS datasets were made available to the researcher. The data was already de-identified and anonymised at the time when data was mined, hence participant consent was not sought to view this data. The research project is registered with the University of the Western Cape (UWC)'s the Higher Degrees Committee. Because the data was publicly available and could only be accessed on request and data were de-identified at the time of mining it, the ethics exemption was granted by the UWC's Humanity and Social Science Research Ethics Committee (HSSREC) (Reference Number: HS20/6/11, see Appendix 4). The accessed data is being used for research purposes only and will be kept in a password-protected computer of the primary investigator for 5 years and discarded thereafter. The primary researcher is the only one who knows the password to the data repository.

CHAPTER FOUR

This chapter presents the outcomes of the current study based on its objectives. These outcomes are presented in three parts: Part 1, showing the basic statistics of the data; Part 2, shows the relationships established between stunting and the indicators/variables across the ten provinces in Zimbabwe; and Part 3, presents maps and visualisation characterising stunting by physical geography in Zimbabwe.

4. Results

4.1. Part 1: The characteristics of the participants and stunting by province



Table 4.1: Percent (%) distribution of child and maternal health, nutrition and socio-demographic characteristics of study population (N) by province, analysis of 2015 ZDHS dataset

		Province (%)										Total (N)
		Manicaland	Mashonaland Central	Mashonaland East	Mashonaland West	Matabeleland North	Matabeleland South	Midlands	Masvingo	Harare	Bulawayo	
Stunted	Height for age <-2SD	30.3	28.7	24.5	27.7	23.5	31.1	27.4	26.8	23.0	18.8	5768
Months of breastfeeding	≤6 months	11.1	8.7	9.1	12.5	8.9	9.6	12.9	10.5	10.1	6.6	722
	7 - 12 months	16.0	12.3	9.2	9.7	9.5	6.6	11.9	8.8	9.7	6.4	455
	13 - 18 months	12.6	14.2	8.9	9.6	9.8	5.3	11.9	12.6	10.1	5.0	437
	19 - 24 months	15.9	9.1	8.0	8.0	11.4	6.8	9.1	13.6	8.0	10.2	88
	>24 months	8.7	8.7	4.3	4.3	13.0	13.0	17.4	8.7	13.0	8.7	23
	Ever breastfed, not currently breastfeeding	11.6	11.5	8.8	12.0	7.6	7.6	11.4	10.2	12.1	7.2	4250
Anaemia	Never breastfed	12.1	6.4	9.6	11.5	10.8	10.2	11.5	8.3	10.8	8.9	157
	Severe	0.9	0.2	0.6	0.0	0.8	0.0	0.4	0.7	0.7	1.0	21
	Moderate	14.3	15.2	15.2	15.0	15.7	17.7	16.0	10.7	19.9	14.5	638
	Mild	25.9	19.4	22.7	25.4	21.3	24.2	22.4	17.5	22.8	20.3	922
Received Vitamin A ₁	Not anaemic	59.0	65.2	61.6	59.6	62.2	58.1	61.1	71.1	56.7	64.1	2572
	No	31.1	29.0	22.6	29.7	19.9	32.0	24.9	25.5	22.6	17.7	903
	Vaccination date on card	51.7	52.4	54.5	45.9	67.3	47.8	46.0	54.7	49.6	61.6	1834
	Reported by mother	15.8	17.8	22.0	23.6	12.7	19.4	27.6	18.8	25.7	20.3	719
	Vaccination marked on card	1.0	0.5	0.3	0.8	0.0	0.0	0.2	0.8	0.5	0.4	17
Ever had vaccination	Don't know	0.5	0.3	0.6	0.0	0.0	0.7	1.2	0.3	1.5	0.0	19
	No	59.4	55.2	41.5	61.4	6.7	9.7	61.6	49.3	27.2	11.9	291
	Yes	40.6	44.8	56.6	38.6	93.3	90.3	34.9	50.7	71.7	88.1	382
	Don't know	0.0	0.0	1.9	0.0	0.0	0.0	3.5	0.0	1.1	0.0	5
	No card	11.9	6.9	7.6	6.2	1.6	3.2	7.0	7.0	0.8	2.5	201

		Province (%)										Total (N)
		Manicaland	Mashonaland Central	Mashonaland East	Mashonaland West	Matabeleland North	Matabeleland South	Midlands	Masvingo	Harare	Bulawayo	
Has health card	Yes, seen	75.2	79.0	79.9	77.7	89.2	76.6	72.9	80.4	76.1	79.7	2736
	Yes, not seen	6.1	11.7	7.3	11.0	4.6	6.1	11.1	4.8	13.2	6.8	298
	No longer has card	6.8	2.4	5.1	5.1	4.6	14.0	9.0	7.8	9.9	11.0	257
Mother's age	15-19	5.8	7.7	7.0	6.2	9.0	9.1	6.7	5.7	2.7	4.4	388
	20-24	24.2	22.8	23.3	25.4	27.9	31.1	26.3	22.5	20.7	27.2	1522
	25-29	28.9	25.4	26.6	25.7	20.7	25.6	28.0	27.2	30.8	25.3	1638
	30-34	24.7	22.2	22.4	20.8	21.7	18.9	21.6	23.7	28.1	23.7	1406
	35-39	9.5	13.1	11.7	16.7	12.4	8.9	11.6	14.6	11.8	14.0	765
	40-44	5.6	7.7	8.1	4.4	6.8	6.1	4.5	5.5	5.3	4.4	355
	45-49	1.2	1.0	0.9	0.8	1.6	0.2	1.3	0.8	0.6	0.9	58
Highest educational level	No education	2.0	2.2	0.2	1.5	0.2	0.6	0.4	1.6	0.0	0.9	63
	Primary	33.0	42.9	29.0	32.9	44.2	26.5	32.1	28.2	10.4	11.4	1806
	Secondary	61.5	51.6	66.8	60.0	52.6	66.9	61.1	63.8	81.3	72.8	3901
	Higher	3.4	3.3	4.0	5.6	3.0	5.9	6.4	6.5	8.3	14.9	362
Number of living children	0	1.0	0.7	0.2	0.8	0.4	0.6	0.7	0.5	0.4	0.9	39
	1	19.4	19.9	22.8	18.1	25.7	29.2	25.6	20.4	23.1	32.6	1414
	2	28.4	24.6	26.4	31.5	29.1	35.2	24.5	31.8	31.1	30.0	1781
	3	21.5	23.7	22.2	21.2	18.7	17.2	20.7	22.3	23.5	18.8	1303
	4	14.4	18.5	14.1	14.6	11.6	7.8	15.5	12.7	12.0	9.8	826
	5	9.9	6.7	8.6	8.3	7.2	5.1	7.8	6.8	7.3	5.1	457
	≥6	5.4	6.0	5.7	5.5	7.4	4.9	5.0	5.5	2.6	2.5	312
Respondent currently working	No	62.5	61.3	49.9	52.2	77.1	67.8	58.5	64.1	49.1	51.2	3620
	Yes	37.5	38.7	50.1	47.8	22.9	32.2	41.5	35.9	50.9	48.8	2512
Type of place of residence	Urban	28.7	21.1	28.4	32.6	25.9	35.2	34.3	24.7	63.6	100.0	2316
	Rural	71.3	78.9	71.6	67.4	74.1	64.8	65.7	75.3	36.4	0.0	3816

N = the combined total number of respondents (women or children) across all provinces with regards to the specific variable that was measured.

The below narrative describes the results presented in Table 4.1.

From the study population, the prevalence of stunting in Zimbabwe ranges from 18.8% in Bulawayo to 31.3% in Matabeleland South, with the combined (national) prevalence of stunting being 27% as measured in the ZDHS. When classified according to WHO thresholds for stunting where $<2.5\%$ = very low; 2.5 to $<10\%$ = low; 10 to $<20\%$ = medium; 20 to $<30\%$ = high and $>30\%$ = very high, then: Bulawayo is the only province with medium stunting prevalence; Mashonaland Central, Mashonaland East, Mashonaland West, Mashonaland North, Midlands, Masvingo and Harare are high, while Manicaland and Matabeleland South are very high.

Midlands and Matabeleland West were the two provinces with the highest proportion of children breastfed for six months or less (12.9% and 12.5% respectively). The proportion of children breastfed for 19 to 24 months was highest in Manicaland (13.6%) followed by Masvingo at 13.6%.

The prevalence of anaemia was the highest in Harare, where 43.4% of the children were anaemic. The lowest was for Masvingo (28.9%). In terms of severity, Harare also had the highest combined proportion of children with moderate and severe anaemia (19.9%), while the lowest was in Mashonaland East with 15% of children being moderately anaemic, there were no severe cases.

Vitamin A₁ was received and recorded on health cards of at least 45% of children across all provinces. Coverage of vitamin A₁ was highest in Bulawayo, where only 17.7% of children had not received supplementation. On the other hand, the proportion of children in Manicaland and Matabeleland South who had not received vitamin A₁ was almost double that of Bulawayo (31.1% and 32%, respectively).

In terms of vaccination, this varied widely by province. Matabeleland North, Matabeleland South and Bulawayo were the provinces with the highest proportions of children who had ever been vaccinated (93.3%, 90.3% and 88.1%, respectively). At the other end of the spectrum, only 34.9% and 38.9% of children in the Midlands and Mashonaland West had ever had vaccination.

Across all provinces, at least 75% of children had a health card that could be seen at the time of the survey.

Matabeleland North (9%) and Matabeleland South (9.1%) had the highest proportion of mothers aged between 15 and 19 years. The lowest was Bulawayo at 4.4%. In fact, over 40% of mothers in Matabeleland South were below the age of 25 years. Harare had the lowest proportion of adolescent mothers, with only 2.7% being aged between 15 and 19 years. Mashonaland West and Mashonaland Central had the highest proportions of mothers aged 35 years and above (21.9% and 20.9%, respectively).

With regards to highest maternal education level, for all provinces, more than half of mothers had attained secondary level - this ranged from 51.6% of mothers in Mashonaland Central to 81.3% of mothers in Harare. At 44.2%, Matabeleland North had the highest proportion of mothers with primary level as the highest education attained, while Mashonaland Central had the highest proportion of mothers who were not educated (2.2%).

Harare was the province with the highest proportion of women having one child. In most provinces, higher proportions of women tended to have two or three children, except for Mashonaland Central which had a comparatively higher proportion of women with four children (18.5%). Matabeleland North was the province with the highest proportion of its women (7.4%) having six or more children.

On maternal employment status, Mashonaland East and Harare had the highest proportion of mothers who were working, 50.1% and 50.9% respectively. As compared to other provinces, Matabeleland North distinctly stood out as having the lowest proportion of mothers who were working with only 22.9% of mothers working, meaning over three-quarters of the mothers were not employed.

Finally, in terms of place of residence, Harare and Bulawayo had the highest proportion of urban inhabitants. In fact, 100% of respondents in Bulawayo were classified as urban followed by Harare at 63.6%. Mashonaland Central (78.9%) and Masvingo (75.3%) had the highest proportion of rural inhabitants.

4.2. Part 2: Association between stunting and selected indicators

The following variables were analysed for association with stunting: breastfeeding anaemia vitamin A₁ mother's age, education level, living children and place of residence. The remaining two variables namely, vaccination and health card were excluded as there were significant gaps in the datasets as follows: vaccination (88.9% of the data was missing) and health card (43.1% of the data was missing). The exclusion was in line with one of the guiding principles of the current study, as outlined earlier in the methodology, which was to only investigate association for variables with complete or near-complete data sets (cut-off point of no more than 10% missing data).

The analysis scale that has been used for determining the strength of the correlations was set accordingly. The provinces in which the results were retrieved were coded in order to show the correlation of the different variables per province. Table 4.2 presents the key of the provincial correlations, followed by Table 4.3 outlining the analysis scale used to determine the strength of correlations.

Table 4.2: Provincial codes

Code	Province
1	Manicaland
2	Mashonaland Central
3	Mashonaland East
4	Mashonaland West
5	Matabeleland North
6	Matabeleland South
7	Midlands
8	Masvingo
9	Harare
10	Bulawayo

Table 4.3: Analysis scale

R-value	Correlation
.00-.19	Very weak
.20-.39	Weak
.40-.59	Moderate
.60-.79	Strong
.80-1.0	Very strong

The results show only weak or very weak correlations with all the different variables in all analyses. In the different results, outliers were identified and removed as noted for each variable.

4.2.1. Association between stunting and months of breastfeeding

Data detailing how long a child was breastfed (duration of breastfeeding) and the stunting levels was normally distributed and continuous by distribution and data types. However, months of breastfeeding contained two significant outliers; 93 and 94 that were removed. Assumptions were met for Pearson's correlation. Based on the provincial data obtained, Table 4.4 illustrates correlations between these two variables in the different provinces.

Table 4.4: Correlation between months of child breastfeeding per province

Code	Province	Finding
1	Manicaland	Weak negative correlation significant at 0.01 ($r = -.291$; $n = 218$; $p = .000$)
2	Mashonaland Central	No significant correlation
3	Mashonaland East	Weak negative correlation significant at 0.05 ($r = -.209$; $n = 138$; $p = .014$).
4	Mashonaland West	Weak negative correlation significant at 0.01 ($r = -.371$; $n = 171$; $p = .000$).
5	Matabeleland North	Very weak negative correlation significant at 0.05 ($r = -.159$; $n = 156$; $p = .047$).
6	Matabeleland South	No significant correlation
7	Midlands	No significant correlation
8	Masvingo	Weak negative correlation significant at 0.01 ($r = -.357$; $n = 173$; $p = .000$).
9	Harare	No significant correlation
10	Bulawayo	No significant correlation

Provinces 1, 3-5 and 8, negative and significant correlations were observed. This suggested that, when the number of months of breastfeeding decreased, the level of stunting increased. For provinces 1, 4 and 8, (i.e. Manicaland, Mashonaland West and Masvingo) the data reveals high significance (all p values are < 0.001). However, the correlation outcomes remained weak (i.e. the r values were less than 0.4).

4.2.2. Association between stunting and anaemia

Data detailing the acquisition of anaemia was categorical (ordinal) data which was normally distributed with no significant outliers in this data. Assumptions for Pearson's were not met therefore a Spearman's correlation was done. Based on the provincial data obtained, Table 4.5 illustrates correlations between these two variables by province.

Table 4.5: Correlation between stunting and anaemia

Code	Province	Finding
1	Manicaland	Very weak positive correlation significant at 0.01 ($r = .123$; $n = 464$; $p = .008$).
2	Mashonaland Central	No significant correlation
3	Mashonaland East	No significant correlation
4	Mashonaland West	No significant correlation
5	Matabeleland North	No significant correlation
6	Matabeleland South	No significant correlation
7	Midlands	No significant correlation
8	Masvingo	No significant correlation
9	Harare	Weak positive correlation significant at 0.01 ($r = .210$; $n = 439$; $p = .000$)
10	Bulawayo	No significant correlation

Positive and significant correlations were identified in two provinces coded 1 and 9. The p-values that are less than 0.001 indicate that these relationships are significant; however, the r values of less than 0.4 also show that the correlation is weak. Since the anaemia variable is coded on a scale of 1=severe anaemia and 4=not anaemic, the findings in the two provinces suggest that the level of anaemia increased with an increase in stunting.

4.2.3. Association between stunting and received Vitamin A₁

Data detailing a child's receipt of Vitamin A₁ was normally distributed and categorical/dichotomous. Categories were merged to make this a yes/no variable. Assumptions were not met for Pearson's therefore a Spearman's correlation was done. Table 4.6 presents the results.

Table 4.6: Correlation between stunting and child receiving Vitamin A₁

Code	Province	Finding
1	Manicaland	No significant correlation
2	Mashonaland Central	No significant correlation
3	Mashonaland East	No significant correlation
4	Mashonaland West	No significant correlation
5	Matabeleland North	No significant correlation
6	Matabeleland South	No significant correlation
7	Midlands	No significant correlation
8	Masvingo	Weak negative correlation significant at 0.01 ($r = -.209$; $n = 328$; $p = .000$)
9	Harare	No significant correlation
10	Bulawayo	No significant correlation

The results showed no correlation for nine of the provinces except province coded 8 (Masvingo) which showed a weak negative and significant correlation ($r = -0.209$; $n = 328$; $p = 0.000$). This suggests that when Vitamin A₁ decreased, stunting increased. The p-value of 0.000 (at $p < 0.01$) showed that the relationship was very significant but remains weak. Also, similar results were retrieved for correlation between stunting and vitamin A₁ in the last 6 months variable in which only Masvingo province had a significant weak negative correlation with stunting ($r = -0.103$; $n = 525$; $p = 0.019$) (data not shown in Table 4.6).

4.2.4. Association between stunting and mother's age

Data detailing the mother's age as well as the stunting levels was normally distributed and continuous by distribution and data types. However, stunting contained three significant outliers; 9996, 9997 and 9998 that were removed while the mother's age contained no significant outliers. Assumptions were met for a Pearson's correlation. Based on the provincial data obtained, Table 4.7 illustrates correlations between these two variables in the different provinces.

Table 4.7: Correlation between stunting and mother's age by province

Code	Province	Finding
1	Manicaland	No significant correlation
2	Mashonaland Central	No significant correlation
3	Mashonaland East	No significant correlation
4	Mashonaland West	No significant correlation
5	Matabeleland North	No significant correlation
6	Matabeleland South	No significant correlation
7	Midlands	No significant correlation

Code	Province	Finding
8	Masvingo	Very weak negative correlation significant at 0.01 ($r = -.166$; $n=528$; $p=.000$)
9	Harare	No significant correlation
10	Bulawayo	No significant correlation

The results showed a very weak negative and significant correlation at 0.01 ($r = -0.166$; $n=528$; $p=0.000$) between stunting and mother's age in Masvingo province. This indicated that, when the mothers' age increased, stunting decreased. P-value of 0.000 showed that the results are highly significant, but this is still a very weak correlation.

4.2.5. Association between stunting and highest maternal level of education

Data detailing the mother's highest level of education was categorical (ordinal) data, which was normally distributed, while the stunting levels was normally distributed and continuous by distribution and data types, respectively. There were no significant outliers. Assumptions for Pearson's were not met, so Spearman's correlation was used. Based on the provincial data obtained, Table 4.8 illustrates correlations between these two variables in the different provinces.

Table 4.8: Correlation between stunting and mother's level of education

Code	Province	Finding
1	Manicaland	Very weak positive correlation significant at 0.01 ($r = .136$; $n= 613$; $p= .001$)
2	Mashonaland Central	Very weak positive correlation significant at 0.01 ($r = .118$; $n= 571$; $p= .005$)

Code	Province	Finding
3	Mashonaland East	Very weak positive correlation significant at 0.01 ($r = .138$; $n = 437$; $p = .004$)
4	Mashonaland West	No significant correlation
5	Matabeleland North	No significant correlation
6	Matabeleland South	No significant correlation
7	Midlands	Very weak positive correlation significant at 0.01 ($r = .159$; $n = 572$; $p = .000$)
8	Masvingo	Very weak positive correlation significant at 0.01 ($r = .141$; $n = 528$; $p = .001$)
9	Harare	Weak positive correlation significant at 0.01 ($r = .207$; $n = 533$; $p = .000$)
10	Bulawayo	Very weak positive correlation significant at 0.05 ($r = .138$; $n = 339$; $p = .011$)

For all the provinces except for provinces 4 and 5, weak and very weak positive correlations were observed. These outcomes show that the level of stunting increases with an increase in the level of education. Moreover, the p-values ranged from 0.000 to 0.005 for provinces coded 1 (0.001), 2 (0.005), 3 (0.004), 7 (0.000), 8 (0.001) and 9 (0.000). This shows that the outcomes are highly significant though the correlation coefficients are very weak.

4.2.6. Association between stunting and number of living children

Data detailing the numbers of living children of the mothers as well as the stunting levels was normally distributed and continuous by distribution and data types. The number of living children did not contain significant outliers. The assumptions were met for Pearson's correlation, and the results are presented in Table 4.9.

Table 4.9: Correlation of stunting with number of living children

Code	Province	Finding
1	Manicaland	No significant correlation
2	Mashonaland Central	No significant correlation
3	Mashonaland East	No significant correlation
4	Mashonaland West	No significant correlation
5	Matabeleland North	No significant correlation
6	Matabeleland South	No significant correlation
7	Midlands	No significant correlation
8	Masvingo	Very weak negative correlation significant at 0.01 ($r = -.197$; $n = 528$; $p = .000$).
9	Harare	Very weak negative correlation significant at 0.01 ($r = -.121$; $n = 533$; $p = .005$).
10	Bulawayo	No significant correlation

The results indicated no significant correlations in eight out of the 10 provinces. The two provinces (coded 8 and 9) showed very weak negative, and significant correlations. This means that the level of stunting increased as the number of children a woman had decreased. Additionally, the p-values of 0.000 and 0.005 also pointed out that the results are highly significant, but still a weak correlation.

4.2.7. Association between stunting and maternal employment

Data detailing the mother's employment status was categorical (dichotomous) data, which was normally distributed, while the stunting levels was normally distributed and continuous by distribution and data types respectively. There were no significant outliers. Assumptions for Pearson's were not met, so Spearman's correlation was used. Table 4.10 presents the results

which show that no significant correlations were found between mother's employment status and stunting in any of the provinces.

Table 4.10: Correlation between stunting and maternal employment status

Code	Province	Finding
1	Manicaland	No significant correlation
2	Mashonaland Central	No significant correlation
3	Mashonaland East	No significant correlation
4	Mashonaland West	No significant correlation
5	Matabeleland North	No significant correlation
6	Matabeleland South	No significant correlation
7	Midlands	No significant correlation
8	Masvingo	No significant correlation
9	Harare	No significant correlation
10	Bulawayo	No significant correlation

4.2.8. Association between stunting and place of residence

Data detailing respondent's place of residence was categorical (dichotomous) data, which was normally distributed, while the stunting levels were normally distributed and continuous by distribution and data types respectively. There were no significant outliers. Assumptions for Pearson's were not met, so Spearman's correlation was used. Table 4.11 presents the results.

Table 4.11: Correlation between stunting and place of residence

Code	Province	Finding
1	Manicaland	Very weak negative correlation significant at 0.01 ($r = -.133$; $n = 613$; $p = .001$)

Code	Province	Finding
2	Mashonaland Central	No significant correlation
3	Mashonaland East	Very weak negative correlation significant at 0.05 ($r = -.116$; $n = 437$; $p = .015$)
4	Mashonaland West	No significant correlation
5	Matabeleland North	There is a very weak negative correlation significant at 0.05 ($r = -.096$; $n = 433$; $p = .046$)
6	Matabeleland South	No significant correlation
7	Midlands	No significant correlation
8	Masvingo	No significant correlation
9	Harare	Very weak negative correlation significant at 0.01 ($r = -.130$; $n = 533$; $p = .003$)
10	Bulawayo	This could not be calculated as all the participants in the province formed part of the urban category

The results showed weak negative and significant correlations for four provinces namely, Manicaland ($r = -0.133$; $n = 613$; $p = 0.001$); Mashonaland East ($r = -0.116$; $n = 437$; $p = 0.015$); Matabeleland North ($r = -0.096$; $n = 433$; $p = 0.046$) and Harare ($r = -0.130$; $n = 533$; $p = 0.003$). This suggests that stunting decreased with urban place of residence. The p-values were all <0.05 showed that the results were highly significant though the correlation outcomes remained very weak (r values were below 0.2).

4.2.9. Multiple regression analysis

Assumptions for conducting multiple regression

All the original variables were included in the multiple regression analysis. The dependent variable (stunting) was measured on a continuous scale while there are two or more

independent variables, which are either continuous or categorical. Additionally, because the collinearity diagnostic appears to be higher than 30 (32.541), we might be concerned that there could be too much multicollinearity. However, on inspecting the variance inflation factor (VIF) values, all of them were between 1 and 5, an indication of mild correlation between independent variables included in the current model. As such, there should be no concern for multicollinearity.

In the current study, the standardised residuals were inspected, and the assumption of normally distributed residuals is therefore met. Following this, a scatter plot was inspected to assess homoscedasticity, and it appears that this assumption holds and there is homoscedasticity. The Durbin-Watson statistic = 1.664 showing that residuals are mostly uncorrelated, therefore this assumption is met, and there appears to be independence of observations. The Cook's D and leverage values were inspected, and it appears that there are no influential cases.

Interpretation of the output

R-squared = 0.200, which means that the independent variables used can predict 20% of the stunting scores. On inspection of the model significance, it is revealed that the overall model is not statistically significant which showed that the regression model is not a good fit for the data. Looking at the independent variables, the data reveals that there is only one statistically significant predictor of stunting, and this is the months of breastfeeding ($p=0.039$) (see Table 4.12). At 5%, none of the other independent variables are statistically significant.

Table 4.12: Results of multiple regression analysis

Coefficients ^a													
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-38.574	159.964		-.241	.811	-360.566	283.417					
	Respondent's current age	9.737	4.961	.484	1.963	.056	-.249	19.723	.078	.278	.259	.287	3.489
	Highest educational level	-60.645	37.886	-.250	-1.601	.116	-136.905	15.615	.012	-.230	-.211	.711	1.406
	Months of breastfeeding	-12.376	5.815	-.316	-2.128	.039	-24.082	-.670	-.169	-.299	-.281	.790	1.267
	Number of living children	-29.884	17.496	-.464	-1.708	.094	-65.103	5.334	-.074	-.244	-.225	.235	4.248
	Respondent currently working	38.993	39.079	.145	.998	.324	-39.669	117.654	.193	.146	.132	.827	1.209
	Has health card	-11.243	57.620	-.042	-.195	.846	-127.226	104.740	.086	-.029	-.026	.376	2.661
	Ever had vaccination	-3.379	42.944	-.013	-.079	.938	-89.821	83.064	.015	-.012	-.010	.662	1.512
	Received Vitamin A1 (most recent)	25.136	49.480	.094	.508	.614	-74.461	124.733	.139	.075	.067	.505	1.982
	Anemia level	19.994	21.196	.140	.943	.350	-22.672	62.660	.052	.138	.124	.790	1.266
	Type of place of residence	-46.971	45.768	-.165	-1.026	.310	-139.097	45.155	-.197	-.150	-.135	.672	1.488

a. Dependent Variable: Height/Age standard deviation (new WHO)

When the part correlation value (circled in green) is squared, the amount of unique variance is attained in accordance to the contribution of dependent variable by each variable. Therefore, breastfeeding contributes 8.94% unique variance.

4.3. Part 3: Characterising stunting by physical geography at provincial level

The current study used mapping and visualisation to describe stunting in relation to physical geography in the different provinces. The variables that were mapped were altitude, climate (rainfall and temperature) and vegetation.

4.3.1. Stunting and altitude

Figure 6 presents the visualisation of stunting with altitude in Zimbabwe.

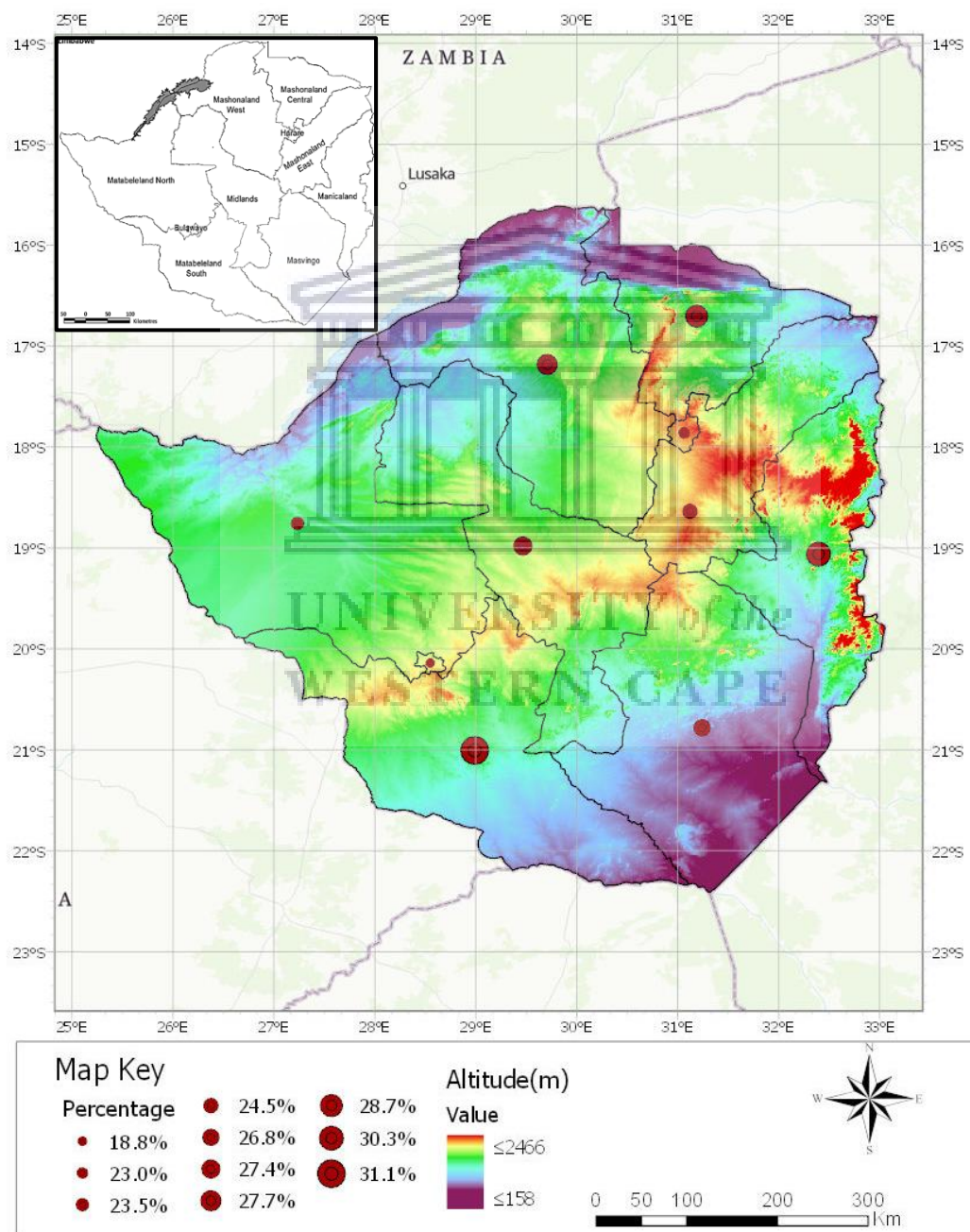


Figure 6: Altitude and stunting prevalence by province

Provinces with very high ($\geq 30\%$) stunting (Matabeleland South and Manicaland): Matabeleland South with the highest prevalence of stunting has a predominantly lower altitude in comparison to Manicaland with the second highest prevalence, also highest altitude in the country. For the remaining provinces (stunting prevalence range from 18.8% to 27.4%), higher prevalence is generally observed in the provinces that lie at higher altitudes.

4.3.2. Stunting and rainfall

Figure 7 presents the visualisation of stunting with rainfall patterns in Zimbabwe.

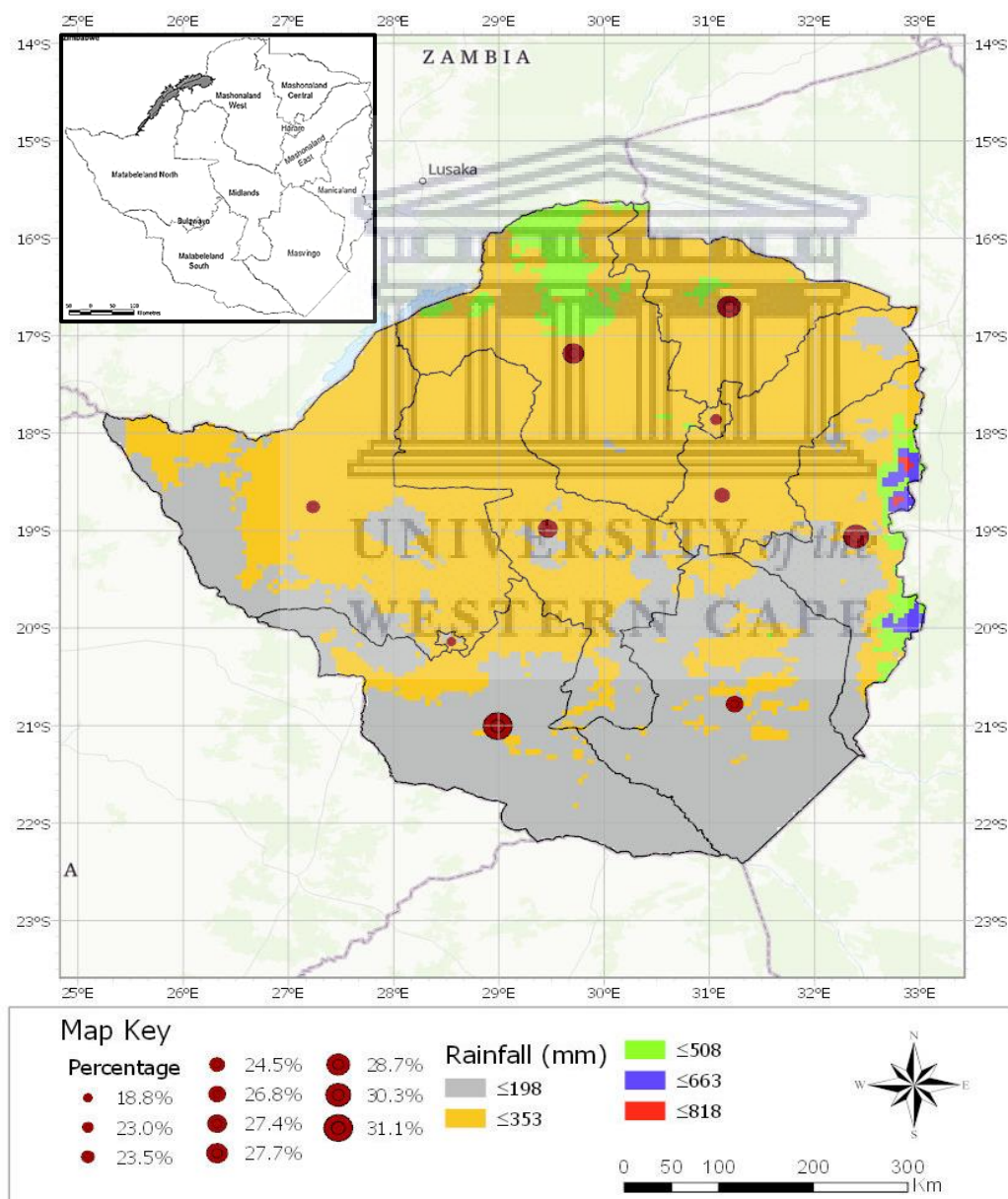
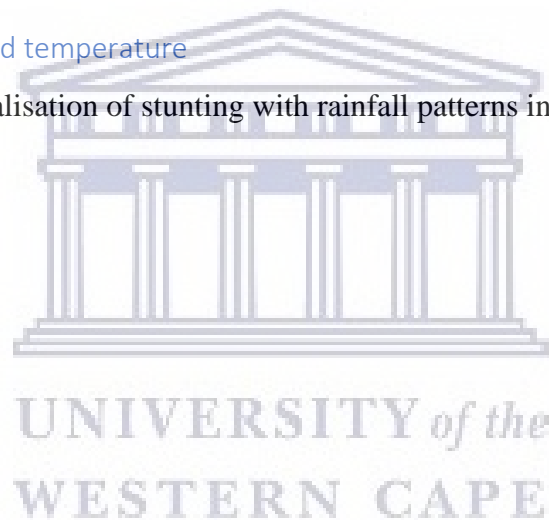


Figure 7: Annual mean rainfall and stunting prevalence by province

In relation to rainfall/precipitation, Matabeleland South, the province with the highest levels of stunting receives the lowest amount of rainfall. On the other hand, Manicaland province, which has the second highest levels of stunting, records the highest rainfall in the country but with some areas of low to moderate rainfall (Figure 7). Provinces with high stunting prevalence (Harare, Mashonaland East, Mashonaland West, Mashonaland Central, Midlands, Matabeleland North and Masvingo) have predominantly low to very low annual rainfall patterns (<350mm) with the exception of Mashonaland West province which has about a fifth of the land receiving moderate rainfall. Lastly, Bulawayo, the only province with medium stunting prevalence (<20%), receives low amounts of rainfall.

4.3.3. Stunting and temperature

Figure 8 presents the visualisation of stunting with rainfall patterns in Zimbabwe.



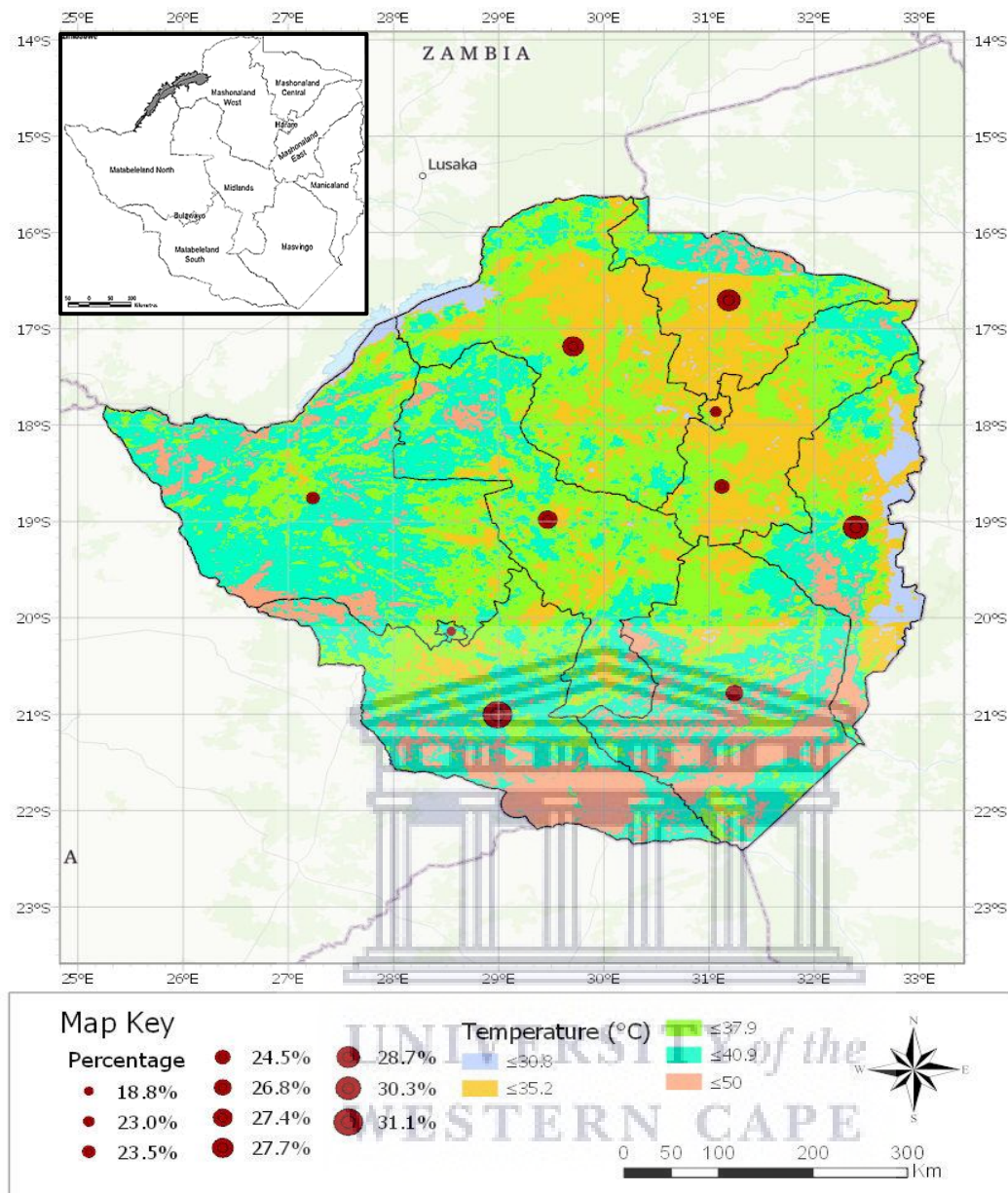


Figure 8: Maximum temperature and stunting prevalence by province

Matabeleland South predominantly has temperatures above 38°C with some parts above 41°C, while Manicaland is the coolest province in the country with temperatures in the eastern most parts falling below 30.8°C. The rest of Manicaland comprises of a mixture of temperatures generally falling between 35°C and 40°C. For provinces with high stunting (20-30%), most are characterised by warm to hot climates. Bulawayo, with the lowest prevalence of stunting has moderate to high temperatures.

4.3.4. Stunting and vegetation type

Figure 9 presents the visualisation of stunting and vegetation type in Zimbabwe.

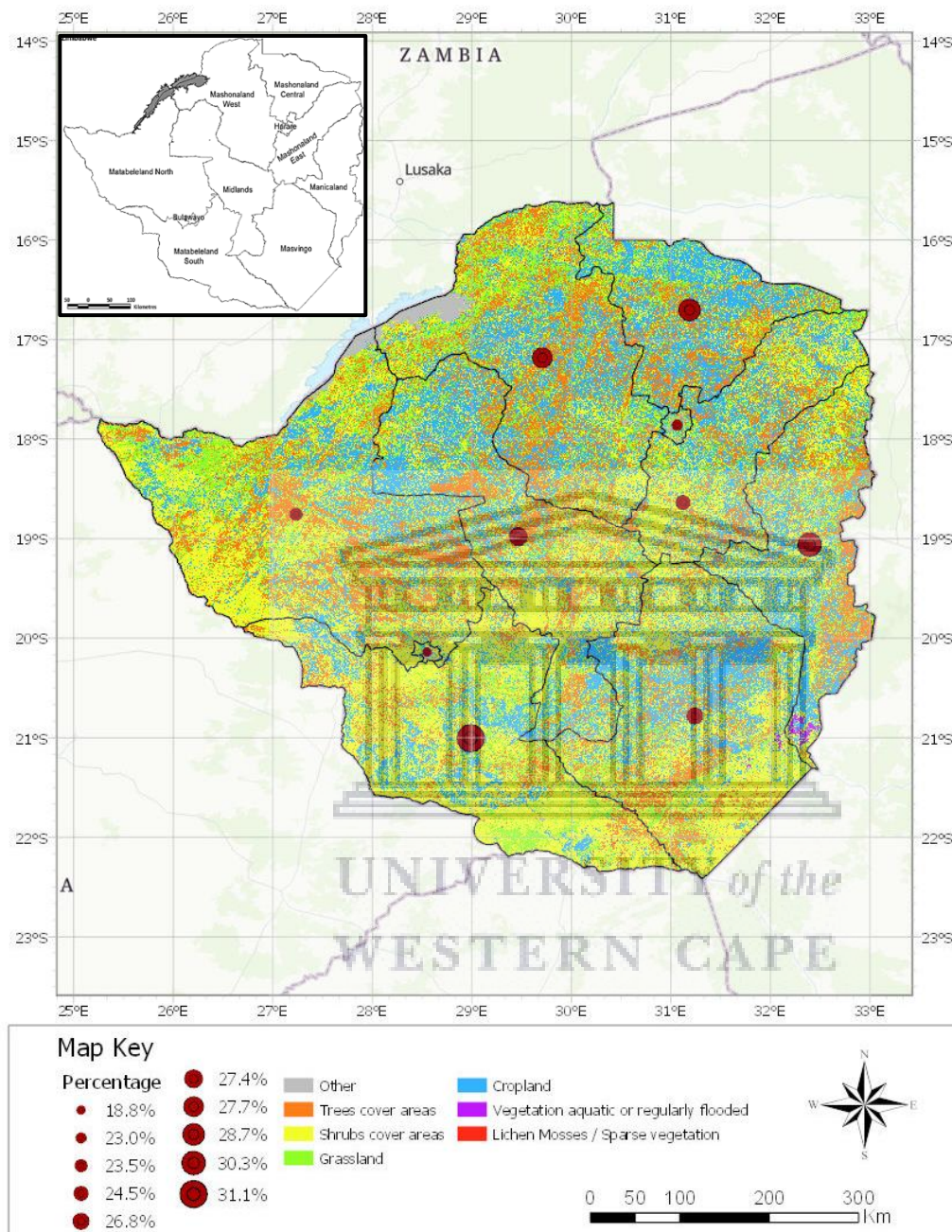


Figure 9: Vegetation and stunting prevalence by province

Matabeleland South with the highest prevalence of stunting in the country is dominated by shrubs with cropland being sparse. On the other hand, Manicaland, with second highest prevalence at 30.3% has a large proportion of the land utilised for crops with higher coverage

of trees. However, the province also has some parts where there are high amounts of rainfall characterised by aquatic vegetation and prone to flooding.



CHAPTER FIVE

This chapter discusses the findings of this study. The discussion reflects on the results of the research and puts some possible explanations for these findings forward, also corroborating or contrasting these findings with available and relevant literature. The limitations of the study are also noted as these contribute to how the findings are interpreted.

5. Discussion

The overall aim of this study was to analyse the association between stunting and maternal and child health, nutrition and socio-demographic factors by province in Zimbabwe, as well as a map and visualise stunting by physical geography, and by province. The variables investigated were:

Health and nutrition-related factors: months breastfed, anaemia, vitamin A₁ supplementation, vaccination status and possession of a health card.

Socio-demographic factors: mother's age, mother's highest level of education, number of living children, mother's employment status and place of residence (urban/rural).

Physical geography: altitude, climate (rainfall and temperature) and vegetation type.

The below discussion is presented in descending order, beginning with the variables that had significant correlations with stunting in most provinces and ending with the least.

5.1. Stunting and mother's highest level of education

Mother's highest level of education stood out as the most cross-cutting factor associated with stunting in Zimbabwe. Interestingly and contrary to other research in Zimbabwe (Maradzika et al., 2016), the current study revealed a significant and positive correlation between stunting and maternal education. This was found in seven out of the ten provinces namely, Bulawayo, Harare, Manicaland, Mashonaland Central, Mashonaland East, Masvingo and Midlands. In

other words, in these provinces, stunting increased with an increase in the level of education of the mother. Previous research conducted in Harare province, which houses the capital of the country, found that low maternal education was a major risk factor for stunting (Maradzika et al., 2016). This was also asserted by Ncube et al. (2020) from their research in Matabeleland South. The finding of the current study is therefore at odds with most research, perhaps the most relevant being the analysis of maternal education and stunting in Malawi, Tanzania and Zimbabwe by Makoko (2013) which was based on the most current DHS data at the time. In the case of Zimbabwe, the DHS data set used was for 2005-6. In the stated research, maternal education was found to be inversely related to stunting. Yaya et al. (2020) also assert that stunting cases in Zimbabwe are higher within rural areas which are characterised by lower education levels, both maternal and paternal. Certainly, for most developing country contexts, higher educational level is a proxy for other socioeconomic indicators such as employment, earning potential and better access to basic goods and services. The general assumption and, often proven to be the case, is that with increased maternal education comes better knowledge and ability to make more informed decisions regarding child health, care and nutrition. Research has found that generally, lower maternal education means poor employment opportunities, lower socioeconomic status, poorer nutrition and limited access to health services (Beal et al., 2018, Zhihui et al., 2020, Maradzika et al., 2016).

On the other side of the coin, the results could also point to globalisation and how this has potentially had an influence and impact on dietary patterns and habits, particularly among the more educated. With higher education comes better job opportunities and higher purchasing power resulting in dietary and lifestyle changes because of increased access to unhealthy foods (Tydeman-Edwards, Van Rooyen and Walsh, 2018). At the same time, excessive marketing, which is almost 'aspirational' in nature, by large multinational food companies has resulted in more educated mothers opting to use breast milk substitutes such as formula milk, instead of

breastfeeding (Kraak et al., 2016). For example, a study in Pakistan found that highly educated mothers were the highest users of formula milk (Hazir et al., 2013). An additional factor that could be at play among women with higher education is that they are more likely to be employed, which may disrupt breastfeeding. In fact, a study in Manicaland (Maxwell et al., 2015) revealed that working mothers were more unable to exclusively breastfeed their children compared to the non-working mothers (58.2% compared to 79.2% were able to exclusively breastfeed). The mothers noted that barriers to the practice included time; lack of support from men; pressure from family to include other foods; lack of interest to breastfeed; and cultural beliefs and practices (Maxwell et al., 2015). Such findings raise the alarm on the general tendency of nutrition implementers to concentrate efforts such as IYCF counselling and promotion towards less educated mothers, based on their socio-demographic vulnerabilities, with few interventions in place for more educated mothers. This study highlights the importance of holistic and inclusive nutrition programmes targeting mothers across different strata.

The above-stated, it is important to note that, over 50% of the participants were women with secondary education, while also across all provinces, less than 2.5% of the participants had no education. This may have influenced the outcome of this association.

5.2. Stunting and duration of breastfeeding

Like other research (Martin, 2001; Magadi, 2011; Yaya et al., 2020) that used evidence from DHS data and had a focus on Africa, the current study found a significant negative correlation between breastfeeding and stunting. In this study, breastfeeding was associated with stunting in five provinces (Manicaland, Matabeleland North, Matabeleland South, Matabeleland West and Masvingo) where stunting was more prevalent among children who were breastfed for a shorter period. The multiple regression analysis also found the duration of breastfeeding to

have the strongest association with stunting. The significance of the findings is even more relevant and telling given that two of the above five provinces namely, Matabeleland South and Manicaland, were also the provinces that recorded the highest stunting rates in the 2015 ZDHS (31.1% and 30.3% respectively). These findings confirm the importance of breastfeeding as part of the first 1,000 days package of cost-effective interventions to prevent stunting. Bhutta et al. (2013) and others (Vesel et al., 2010; Magadi, 2011; Yaya et al., 2020) confirm the link between duration of breastfeeding and child nutritional status, including vertical/linear growth. Beal et al. (2018) highlighted the role of exclusive breastfeeding for the first six months of life as crucial. Breast milk is known to provide complete nutrition to meet all the energy and nutrient requirements of a child for the first six months, followed by appropriate complementary feeding (Marriott et al., 2012). Indicatively, a reduction in the length of breastfeeding means that a child cannot attain the full nutritional benefits of breast milk (Beal et al., 2018).

While some research (Syeda et al., 2020) cautions around prolonged breastfeeding and that this might pose a significant risk for stunting, the overwhelming evidence is, for the most part, that the benefits of breastfeeding far outweigh any potential negative effects with regards to stunting in children. The results of the current study support this.

5.3. Stunting and place of residence

The current study found a significant and negative correlation between stunting and residing in an urban area in Manicaland, Mashonaland East, Matabeleland North and Harare. In these provinces, stunting was lower among urban inhabitants. This finding is supported by wide research in Sub-Saharan Africa (Keino et al., 2014), Zimbabwe (Maradzika et al., 2016), Indonesia (Beal et al., 2018; Wicaksono and Harsanti, 2020). This suggests that in the stated provinces of Zimbabwe, intensity of efforts, including allocation of resources for stunting prevention programmes should be prioritised to the more rural settings.

5.4. Stunting and childhood anaemia

The current study found positive and significant correlations between stunting and anaemia in children in Harare and Manicaland provinces. This finding is in line with other studies that have found this positive association and, specifically, that the more severe the anaemia, the more likely a child is to be stunted (Malako et al., 2019; Hailu, Bogale and Beyene, 2020). A 2018 analysis of large-scale household data found 81% of stunted children below the age of five had iron deficiency anaemia (Kairiza et al., 2020). This association between stunting and anaemia can possibly be explained by the fact that stunting and anaemia often have poor dietary intake and/or disease as common denominators (Geda et al., 2021). Of interest to note is the finding for Harare province, which is also the capital of Zimbabwe. The correlation between stunting and anaemia in the predominantly urban setting potentially speaks to issues around access to healthy diets. This could point to the effects of globalisation on dietary patterns and habits of dwellers in urban and peri-urban communities and is an area that could benefit from further research.

On the one hand, people in urban settings have over time adopted a more 'westernised' lifestyle with a tendency to move away from traditional diets, which are more balanced and nutritious (Tydeman-Edwards, Van Rooyen and Walsh, 2018). Essentially, this compromises the quality of the diet children consume and may affect micronutrient status. At the other end of the spectrum, however, and perhaps more relevant in the Zimbabwe context, are the effects that the mass rural-urban migration over the last decade have had in terms of affordability of healthy diets among the urban poor (Muchadenyika and Williams, 2016). Although not widely researched, urbanisation could compromise the ability to access and consume iron-rich foods which are mainly found in animal protein sources (Horton, Alderman and Rivera, 2008), often not within reach of rural to urban migrants. Therefore, programming with a focus on addressing the nutritional needs among urban vulnerable is an important consideration.

5.5. Stunting and number of living children

The results of this study revealed a negative correlation between stunting and the number of living children in Masvingo and Harare provinces. For the remaining provinces, there was no significant correlation between stunting and the number of children a woman had. The latter aligns with Kravdal and Kodzi (2011), who assert that, at best, a very weak association exists between stunting and the number of children. Findings from a meta-analysis of DHS data for 35 countries in Sub-Saharan Africa (Yaya et al., 2020) indicate that shorter birth intervals, not necessarily the number of children, could be a stronger determinant for stunting. Another consideration is that mothers with more living children might have the advantage of a stronger support network at home. For example, older children in the home might take on more responsibilities in terms of household chores and in so doing, free the mother up to care for the younger children in terms of feeding and other infant and child-care practices.

5.6. Stunting and vitamin A supplementation

Except for Masvingo province, the results did not reveal any significant correlation between stunting and a child receiving vitamin A supplementation across all provinces in Zimbabwe. Masvingo showed a significant negative correlation where stunting was more prevalent among children who had not received vitamin A supplementation. This was the case for both 'received vitamin A₁' and 'received vitamin A in the last six months'. These findings suggest that while a clear cause and effect link between stunting and vitamin A supplementation has not been clearly established for Zimbabwe, there may be context-specific variations, in this case, Masvingo province which may warrant further investigation. While there is also limited research globally on the association between stunting and vitamin A supplementation in children, a randomised controlled trial in Indonesia revealed that vitamin A supplementation improved linear growth among preschool children (Hadi et al., 2000). In their research, which

analysed 2008 DHS data in Kenya, Kimani-Murage et al. (2013) also found that receiving vitamin A supplementation was significantly negatively associated with stunting in children under the age of two.

Whether or not children received vitamin A supplementation not only speaks to the physiological or health benefits to an individual of doing so, but also sheds light to other contextual factors. For example, in settings where vitamin A supplementation is provided at healthcare facilities, adherence of primary caregivers to vitamin A schedules also speaks to health seeking behaviour. At the same time, in contexts where vitamin A supplementation is primarily delivered through mass campaigns, the number of children who received vitamin A supplementation informs on the success of such campaigns in terms of coverage and access. As such, research that probes more on vitamin A supplementation and its links to stunting could also provide insights into other important factors for consideration in broader public health and nutrition programming.

5.7. Stunting and mother's age

Like vitamin A supplementation, mother's age was also only significantly correlated with stunting in Masvingo. The correlation was negative, that is, stunting decreased as the age of the mother increased. The findings align with other studies that have observed lower stunting rates with increasing age of the mother (Nguyen et al., 2019; Chirande et al., 2015; Darteh, Acquah and Kumi-Kyereme, 2014; Mzumara et al., 2014). The finding for Masvingo province is also consistent with a review by Yaya et al. (2020) that found that, in Zimbabwe, children born to younger mothers were more prone to stunting. This group of mothers was characterised by lower education, knowledge and awareness on various issues including antenatal care, appropriate IYCF, hygiene (Yaya et al., 2020).

5.8. Stunting and maternal employment status

Whether a mother is employed or not has economic and social effects which extend to the health and nutrition of a child. Increased income contributes to improved access to food, health care and other essential services (Ukwuani and Suchindran, 2003). This is more so when it is a woman generating the earning. It is well established and backed by research that when women are in empowered and have control over money, this has a positive effect on health and nutritional outcomes of children (Shroff et al., 2011). On the other end of the spectrum, when a mother is employed this entails longer time spent away from home which can have negative impact in terms of engaging in optimal IYCF practices such as timely breastfeeding and consumption of appropriate complementary foods (Waldfoegel, 2002). Notwithstanding the above, the current study did not find any significant correlation between stunting and mother's employment status in any of the provinces. This aligns with findings by Eshete et al. (2017) and Chavez-Zarate et al. (2019) whose research revealed no associations between the two variables.

5.9. Insights on stunting and physical geography

While the mapping and visualisation of stunting by factors linked to physical geography was done at provincial level, therefore not as granular as what would have been observed if mapping had been done at a lower level such as district or sub-district level, there are some clear insights from the exercise. In fact, despite spatial analysis or other techniques not being fully applied, given the extent of aggregation of the data, the visual observations particularly from mapping of the two provinces of Matabeleland South and Manicaland which have the highest stunting rates in the country (>30%, classified as very high), begin to paint a picture which can be further illuminated with further research. The mapping exercise showed that Matabeleland South province, with the highest stunting prevalence in the country, has very low rainfall patterns and is dominated by temperatures above 38°C. Very high temperature has been established as a

determinant of stunting in several studies (Hagos et al., 2014; Bharti, Dhillon and Narzary, 2019), while literature also supports that low rainfall, especially in drought prone areas, may be a key driver of stunting (Hagos et al., 2014; Cooper et al., 2019). Manicaland, which has the second highest stunting prevalence nationally, is the province lying at the highest altitude in the country. The highest elevation is close to 2,500 metres above sea level. The province also receives the highest aggregate rainfall in the country and, based on the vegetation map, some are prone to flooding. While not an extensively researched area, a few studies that have been conducted have revealed a positive association between stunting and altitude (Dang, Yan and Yamamoto, 2008; Mohammed et al., 2020) and that the negative effects of this begin during pregnancy (Baye, Hirvonen and Wu, 2020). Cooper et al. (2019) have revealed that excessive rainfall can also be a problem. In their research, areas prone to flooding were associated with poor stunting outcomes (Cooper et al., 2019). This could be due to crops being destroyed by the rains. The effect of this is decreased food security at the household and individual levels, particularly in communities that rely on agricultural yield for food consumption and as a source of livelihood.

Zimbabwe is divided into five natural regions as presented in Figure 10, Region I is the most favourable for intensive farming of cash crops including tea and coffee, as well as beef, maize, dairy and fruits (Masarakufa, 2020). As seen in Figure 10, most of Manicaland province lies in this region. On the other end of the scale lies Region V, which is characterised by extensive farming as it has very low agricultural productivity potential, hence a limited focus on maize and other small grains (Masarakufa, 2020). Half of Matabeleland South, most parts of Masvingo, and parts of Matabeleland North, Midlands and Mashonaland West provinces fall in this region. It is interesting to note that despite the high agricultural yield and diversified crop production in Manicaland, it has very high stunting rates in children. This implies that there could also be some behavioural or cultural issues at play, which were not included within

the scope of the current study. It also shows that the availability of food does not necessarily translate to access and consumption, as there are other factors that influence nutritional behaviours, and these also need to be understood in order to address them.

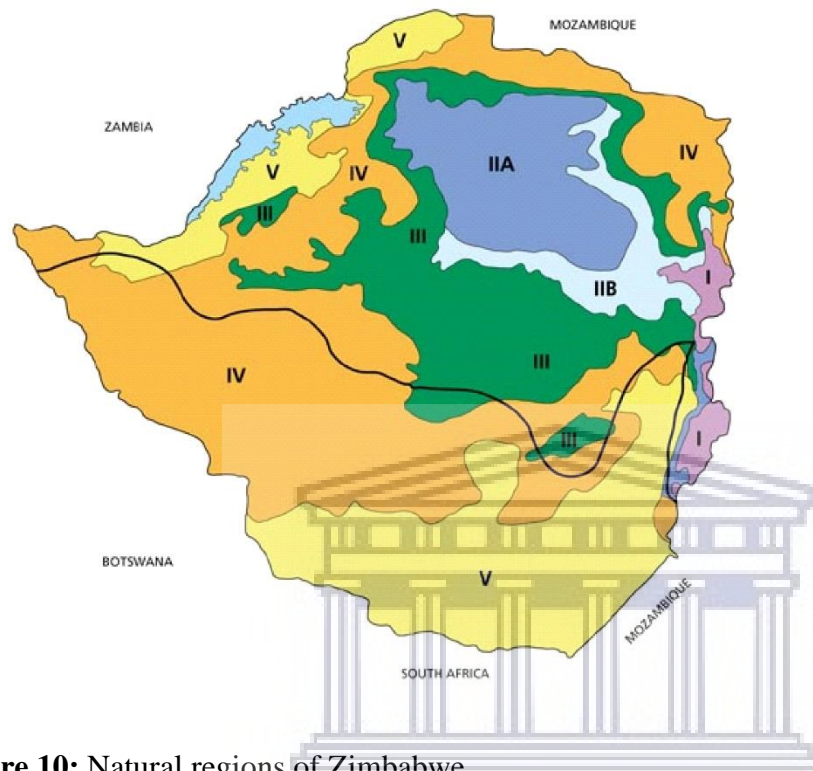


Figure 10: Natural regions of Zimbabwe

Source: Poulisse and Van den Bergen (2006)

The overall observations from the visual mapping exercise are particularly relevant given the emerging issue of climate change and its impacts globally. This begs the question of the extent to which climate change has an effect on nutritional outcomes including stunting. Already, modelling exercises in the region predict an up to 23% increase in severe stunting in Sub-Saharan Africa in the next 30 years if the current conditions related to climate change continue with little to no intervention (Lloyd, Kovats and Chalabi, 2011). Researchers have also forecast that climate change could particularly increase stunting in regions that are highly dependent on rain for agriculture (Grace et al., 2012). Zimbabwe is such a country. Not only is most of the country dependent on rain-fed agriculture, but also, the geographical landscape does not favour much intensive farming of diversified crops (Poulisse and Van den Bergen, 2006). Therefore,

any further deterioration in terms of climate will mean extended dry periods in drought-prone regions. In the absence of other interventions or innovations, this could, through several direct and indirect links, ultimately result in more children becoming stunted.

5.10. Limitations of the study

While this study has many important outcomes, there are limitations that need to be considered. For instance, the current study is based on secondary ZDHS data that was collected in 2015. As such, the depth of descriptive analysis is limited to the confines of the outcomes of the indicators that were collected for the ZDHS study. For example, the lowest geographical level of data collected for the 2015 ZDHS was at the provincial level. The provincial level is therefore, the lowest level of analysis that can be conducted for the current study. Likewise, the mapping and visualisation of stunting by physical geography was kept high level as there were not many data points, for example, district level stunting data, to enable further zooming in and undertaking of spatial and hotspot analysis.

Furthermore, while 2015 is the latest year in which a DHS was undertaken in Zimbabwe, the data is five years old. While indeed stunting is a chronic indicator (Black et al., 2008), there have been some changes in the Zimbabwe nutrition trajectory since the 2015 ZDHS. To circumvent this, the literature review has been comprehensive to ensure that the most recent literature and evidence on the stunting landscape in Zimbabwe is given due consideration particularly when discussing the study results. Lastly, given the complexity of stunting and its drivers, it is acknowledged that there may be unidentified confounders that may remain unaddressed in the study. However, it is important to note that this was minimised by identifying and controlling for the most relevant and known confounding factors for stunting that were available in the ZDHS database.

CHAPTER SIX

This chapter presents the conclusion and recommendations from the current study. The focus is around findings that were of significance in the current study and to the extent possible, province-specific recommendations are provided. Areas for consideration in future research are included in the conclusion.

6. Conclusion and Recommendations

6.1. Conclusion

Stunting has been noted to still be high in Zimbabwe and found to be related to conditions and characteristics that range from individual to maternal, societal and environmental, among others. In order to make better informed policy and programmatic decisions, it is essential to gain an appreciation of the factors contributing to stunting and explore these different associations at lower geographical levels.

From the results of the current secondary study based on provincial level data from the 2015 ZDHS, one can conclude that within the context of Zimbabwe, duration of breastfeeding is the maternal/child health and nutrition variable most associated with stunting. However, the study revealed gaps in literature specifically around the potential effect of urbanisation on IYCF among more educated mothers. This was further underpinned by the association between stunting and anaemia in provinces with relatively higher populations in Zimbabwe.

With regards to sociodemographic characteristics, maternal education level is the variable most associated with stunting at provincial level. The mapping and visualisation exercise also highlighted that physical geography characteristics namely, altitude, temperature, rainfall and vegetation, which were investigated in the study, may also play a role in driving stunting at the provincial level in Zimbabwe.

6.2. Main recommendations

Recommendation 1: Scale-up promotion of infant and young child feeding

The current study showed a significant and negative correlation between stunting and duration of breastfeeding in five provinces. Based on this finding, the importance of breastfeeding as a protective intervention cannot be overstated. Provinces, in particular, Manicaland, Matabeleland North, Matabeleland South, Matabeleland West and Masvingo need to ensure increased coverage and availability of interventions that promote and support IYCF. In order to be comprehensive, these should be informed by formative research to understand the barriers to breastfeeding by location then subsequently put in place context-specific measures (Bentley et al., 2014). Also given the wide variation in the type of residence that is rural versus urban, service provision should be planned in a way that ensures the widest reach possible. This entails investment in more community outreach and household level programmes in settings where mothers might struggle to access health services (UNICEF, 2014).

From a policy perspective, due consideration should be made to create an enabling environment for mothers to be able to practice exclusive breastfeeding for the first six months. This could include flexible work hours for nursing mothers or provision of clean, safe and respectful facilities in the workplace for nursing mothers to express milk (Rollins et al., 2016).

Recommendation 2: Invest in targeted social and behaviour change communication

Seven of the 10 provinces in Zimbabwe revealed a positive correlation between stunting and level of education. This indicates a need to ensure that all mothers, regardless of education level, must continuously be reached with communication to reinforce key health and nutrition messages and ensure that no one segment is inadvertently left behind or missed out. Social and behaviour communication (SBCC) can be spread through various platforms including radio, social media and television across different demographics (Raftree, 2019). It is important for provinces to work with SBCC specialists who are experienced in developing messaging for

different audience groups. In other words, provinces need to avoid the 'one size fits all' approach but rather invest in the right resources to develop evidence-based solutions and messages that are contextualised to the population group (Kodish et al., 2015).

Recommendation 3: Implement contextualised solutions to address micronutrient deficiencies

While the current study revealed a significant positive correlation between stunting and anaemia in only two provinces (Manicaland and Harare) and significant negative correlation between stunting and vitamin A supplementation in only one province (Masvingo), the anaemia data shows a big problem around micronutrient deficiencies in Zimbabwe. Secondly, when looking at the physical geography characteristics of provinces, including vegetation type and temperature, one can make some inferences with regards to the adequacy of diets that are primarily dependent on agricultural yield. Solutions to address micronutrient deficiencies need to be informed by the prevailing challenges in a province (Mason et al., 2006). For example, Masvingo could roll-out mass Vitamin A campaigns which have been found to increase coverage of vitamin A in similar predominantly rural contexts (Aguayo et al., 2005; Masanja et al., 2006; Horton et al., 2018). In the case of Harare, more programming targeted at urban poor populations may be required, including cost-effective interventions such as home fortification with micronutrient powders for young children (Siekman et al., 2017). For Manicaland, on the other hand, given the evidence points to it being for the large part a fertile region which produces very diversified crops, the issue here could be linked to knowledge. Evidence points to the most appropriate interventions for such a setting being those with a focus on improving knowledge, attitudes and practices around IYCF practices (Sunguya et al., 2014).

Opportunities for future research

The findings of the study reveal several gaps in literature that present opportunity for future research. Firstly, techniques such as spatial analysis based on linking nutrition data to

geographical coordinates at a more granular level for example, at district or ward level present an opportunity to not only identify main problems in a geographical location but also zoom into specific hotspots and quantify these based on modelling. This level of interactive data will in turn improve specificity and targeting of nutrition interventions. Further research also needs to be undertaken to define the association between stunting and climate-related variables such as rainfall and temperature. As climate change continues to be among the biggest global concerns of this century and its impacts are increasingly felt in terms of changing weather patterns and seasons, modelling the effects of climate change on stunting in Zimbabwe is important to inform future programming. The study indeed revealed that linking stunting or other forms of malnutrition to physical geography is a novel approach that has not been widely investigated especially in Sub-Saharan Africa.

Given that stunting and anaemia are among the top global issues of significant public health concern, coexistence of these two conditions is of particular concern. More investigation is needed to better understand the underlying factors driving stunting and anaemia in Zimbabwe. One of the focus areas of such an investigation should be to zoom in on the potential effects of urbanisation, from the perspective of how urban food systems may be driving all forms of malnutrition, beyond stunting and anaemia.

REFERENCES

- Abeway, S., Gebremichael, B., Murugan, R., Assefa, M. and Adinew, Y.M., 2018. Stunting and its determinants among children aged 6-59 months in Northern Ethiopia: A cross-sectional study. *Journal of Nutrition and Metabolism*, [e-journal] pp.1-8.
<https://doi.org/10.1155/2018/1078480>
- Adebisi, Y.A., Ibrahim, K., Lucero-Prisno, D.E., Ekpenyong, A., Micheal, A.I., Chinemelum, I.G. and Sina-Odunsi, A.B., 2019. Prevalence of socio-economic impacts of malnutrition among children in Uganda. *Nutrition and Metabolic Insights*, [e-journal]
<https://doi.org/10.1177/1178638819887398>
- Aguayo, V.M., Baker, S.K., Crespín, X., Hamani, H. and Mamadoul Taïbou, A., 2005. Maintaining high vitamin A supplementation coverage in children: Lessons from Niger. *Food and Nutrition Bulletin*, [e-journal] 26(1), pp.26-31.
<https://doi.org/10.1177/156482650502600103>
- Akombi, B.J., Agho, K.E., Merom, D., Renzaho, A.M. and Hall, J.J., 2017. Child malnutrition in Sub-Saharan Africa: A meta-analysis of demographic and health surveys (2006-2016). *PLoS One*, [e-journal] 12(5), p.e0177338.
<https://doi.org/10.1371/journal.pone.0177338>
- Alderman, H., 2010. The economic cost of a poor start to life. *Journal of Developmental Origins of Health and Disease*, [e-journal] 1(1), pp.19-25.
<https://doi.org/10.1017/S2040174409990158>
- Asiki, G., Newton, R., Marions, L., Kamali, A. and Smedman, L., 2019. The effect of childhood stunting and wasting on adolescent cardiovascular diseases risk and educational achievement in rural Uganda: A retrospective cohort study. *Global Health Action*, [e-journal] 12(1), p.1626184. <https://doi.org/10.1080/16549716.2019.1626184>
- Asuman, D., Ackah, C.G., Fenny, A.P. and Agyire-Tettey, F., 2019. Assessing socioeconomic inequalities in the reduction of child stunting in sub-Saharan Africa. *Journal of Public Health*, [e-journal] 28(5), pp.563-573. <https://doi.org/10.1007/s10389-019-01068-2>
- Baye, K., Hirvonen, K. and Wu., 2020. *High altitudes linked to higher rates of stunting*. Washington: International Food Policy Research Institute.

Beal, T., Tumilowicz, A., Sutrisna, A., Izwardy, D. and Neufeld, L.M., 2018. A review of child stunting determinants in Indonesia. *Maternal and Child Nutrition*, [e-journal] 14(4), p.e12617. <https://doi.org/10.1111/mcn.12617>

Bentley, M.E., Johnson, S.L., Wasser, H., Creed-Kanashiro, H., Shroff, M., Fernandez-Rao, S. and Cunningham, M., 2014. Formative research methods for designing culturally appropriate, integrated child nutrition and development interventions: an overview. *Annals of the New York Academy of Sciences*, [e-journal] 1308, p.54. <https://doi.org/10.1111/nyas.12290>

Berhe, K., Seid, O., Gebremariam, Y., Berhe, A. and Etsay, N., 2019. Risk factors of stunting (chronic undernutrition) of children aged 6 to 24 months in Mekelle City, Tigray Region, North Ethiopia: An unmatched case-control study. *PLoS One*, [e-journal] 14(6), p.e0217736. <https://doi.org/10.1371/journal.pone.0217736>

Bharti, R., Dhillon, P. and Narzary, P.K., 2019. A spatial analysis of childhood stunting and its contextual correlates in India. *Clinical Epidemiology and Global Health*, [e-journal] 7(3), pp.488-495. <https://doi.org/10.1016/j.cegh.2019.04.005>

Bhutta, Z.A., Ahmed, T., Black, R.E., Cousens, S., Dewey, K., Giugliani, E., Haider, B.A., Kirkwood, B., Morris, S.S., Sachdev, H.P.S. and Shekar, M., 2008. What works? Interventions for maternal and child undernutrition and survival. *The Lancet*, [e-journal] 371(9610), pp.417-440. [https://doi.org/10.1016/S0140-6736\(07\)61693-6](https://doi.org/10.1016/S0140-6736(07)61693-6)

Bhutta, Z.A., Das, J.K., Rizvi, A., Gaffey, M.F., Walker, N., Horton, S., Webb, P., Lartey, A., Black, R.E., The Lancet Nutrition Interventions Review Group and the Maternal and Child Nutrition Study Group, 2013. Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? *The Lancet*, [e-journal] 382(9890), pp.452-477. [https://doi.org/10.1016/S0140-6736\(13\)60996-4](https://doi.org/10.1016/S0140-6736(13)60996-4)

Black, R. E., Allen, L. H., Bhutta, Z. A., Caulfield, L. A., de Onis, M., Ezzati, M., Mathers, C., and Rivera, J. 2008. For the Maternal and Child Undernutrition Study Group: Global and Regional Exposures and Health Consequences. *The Lancet*, [e-journal] 371(9608), pp.243-260. [https://doi.org/10.1016/S0140-6736\(07\)61690-0](https://doi.org/10.1016/S0140-6736(07)61690-0)

Black, R.E., Victora, C.G., Walker, S.P., Bhutta, Z.A., Christian, P., De Onis, M., Ezzati, M., Grantham-McGregor, S., Katz, J., Martorell, R. and Uauy, R., 2013. Maternal and child undernutrition and overweight in low-income and middle-income countries. *The Lancet*, [e-journal] 382(9890), pp.427-451. [https://doi.org/10.1016/S0140-6736\(13\)60937-X](https://doi.org/10.1016/S0140-6736(13)60937-X)

- Boah, M., Azupogo, F., Amporfro, D.A. and Abada, L.A., 2019. The epidemiology of undernutrition and its determinants in children under five years in Ghana. *PloS One*, [e-journal] 14(7), p.e0219665. <https://doi.org/10.1371/journal.pone.0219665>
- Buisman, L.R., Van de Poel, E., O'Donnell, O. and van Doorslaer, E., 2019. What explains the fall in child stunting in Sub-Saharan Africa? *SSM-Population Health*, [e-journal] 8, p.100384. <https://doi.org/10.1016/j.ssmph.2019.100384>
- Caulfield, L.E., Richard, S.A., Rivera, J.A., Musgrove, P. and Black, R.E., 2006. Stunting, wasting, and micronutrient deficiency disorders. In *Disease Control Priorities in Developing Countries. 2nd edition*. The International Bank for Reconstruction and Development/The World Bank.
- Chakravarty, N., Tatwadi, K. and Ravi, K., 2019. Intergenerational effects of stunting on human capital: Where does the compass point? *International Journal of Medicine and Public Health*, [e-journal] 9(4), pp.105-111. <https://doi.org/10.5530/ijmedph.2019.4.24>
- Chávez-Zárate, A., Maguiña, J.L., Quichiz-Lara, A.D., Zapata-Fajardo, P.E. and Mayta-Tristán, P., 2019. Relationship between stunting in children 6 to 36 months of age and maternal employment status in Peru: A sub-analysis of the Peruvian Demographic and Health Survey. *PLoS One*, 14(4), p.e0212164. <https://doi.org/10.1371/journal.pone.0212164>
- Chidziwisano, K., Slekiene, J., Kumwenda, S., Mosler, H.J. and Morse, T., 2019. Toward complementary food hygiene practices among child caregivers in rural Malawi. *The American Journal of Tropical Medicine and Hygiene*, [e-journal] 101(2), pp.294-303. <https://doi.org/10.4269/ajtmh.18-0639>
- Chirande, L., Charwe, D., Mbwana, H., Victor, R., Kimboka, S., Issaka, A.I., Baines, S.K., Cooper, M.W., Brown, M.E., Hochrainer-Stigler, S., Pflug, G., McCallum, I., Fritz, S., Silva, J. and Zvoleff, A., 2019. Mapping the effects of drought on child stunting. *PNAS*, [e-journal] 116(35), pp.17219-17224. <https://doi.org/10.1073/pnas.1905228116>
- Cost of Hunger in Africa (COHA) Study, 2013. *Social and Economic Impact of Child Undernutrition in Egypt, Ethiopia, Swaziland and Uganda*. Addis Ababa: United Nations Economic Commission and Africa.
- Creswell, J.M., 2014. *Research Design. Qualitative, quantitative and mixed methods approaches*. Sage Publications.

Dandajena, G., 2013. *Factors Associated with Chronic Malnutrition in Mazowe District, Mashonaland Central Province 2012*. [online] Available at: <
<http://hdl.handle.net/10646/1328>> [Accessed 8 August 2020].

Dang, S., Yan, H. and Yamamoto, S., 2008. High altitude and early childhood growth retardation: new evidence from Tibet. *European Journal of Clinical Nutrition*, [e-journal] 62(3), pp.342-348. <https://doi.org/10.1038/sj.ejcn.1602711>

Darteh, E.K.M., Acquah, E. and Kumi-Kyereme, A., 2014. Correlates of stunting among children in Ghana. *BMC Public Health*, [e-journal] 14(1), p.504.
<https://doi.org/10.1186/1471-2458-14-504>

DeBoer, M.D., Lima, A.A., Oría, R.B., Scharf, R.J., Moore, S.R., Luna, M.A. and Guerrant, R.L., 2012. Early childhood growth failure and the developmental origins of adult disease: Do enteric infections and malnutrition increase risk for the metabolic syndrome? *Nutrition Reviews*, [e-journal] 70(11), pp.642-653. <https://doi.org/10.1111/j.1753-4887.2012.00543.x>

De Groot, R., Handa, S., Ragno, L.P. and Spadafora, T., 2020. Child malnutrition, consumption growth, maternal care and price shocks: New evidence from Northern Ghana. *Development Studies Research*, [e-journal] 7(1), pp.18-30.
<https://doi.org/10.1080/21665095.2020.1722721>

De Onis, M. and Branca, F., 2016. Childhood stunting: A global perspective. *Maternal and Child Nutrition*. [e-journal] 12 (Suppl 1), pp.12-26. <https://doi.org/10.1111/mcn.12231>

De Onis, M., Borghi, E., Arimond, M., Webb, P., Croft, T., Saha, K., De-Regil, L., Thuita, F., Heidkamp, R., Krasevec, J., Hayashi, C. and Flores-Ayala, R., 2018. Prevalence thresholds for wasting, overweight and stunting in children under 5 years. *Public Health Nutrition*, [e-journal] 22(1):175-179. <https://doi.org/10.1017/S1368980018002434>

Dewey, K.G. and Begum, K., 2011. Long-term consequences of stunting in early life. *Maternal and Child Nutrition*, [e-journal] 7, pp.5-18. <https://doi.org/10.1111/j.1740-8709.2011.00349.x>

Dinh, D.M., Ramadass, B., Kattula, D., Sarkar, R., Braunstein, P., Tai, A., Wanke, C.A., Hassoun, S., Kane, A.V., Naumova, E.N. and Kang, G., 2016. Longitudinal analysis of the intestinal microbiota in persistently stunted young children in South India. *PLoS One*, [e-journal] 11(5), p.e0155405. <https://doi.org/10.1371/journal.pone.0155405>

Eshete, H., Abebe, Y., Loha, E., Gebru, T. and TesHEME, T., 2017. Nutritional status and effect of maternal employment among children aged 6–59 months in Wolayta Sodo town, southern Ethiopia: a cross-sectional study. *Ethiopian Journal of Health Sciences*, [e-journal] 27(2), pp.155-162. [doi:10.4314/ejhs.v27i2.8](https://doi.org/10.4314/ejhs.v27i2.8).

European Commission (EC), 2015. *We Can Overcome Undernutrition: Zimbabwe Case Study*. [pdf] Available at :
<https://ec.europa.eu/europeaid/sites/devco/files/zimbabwe_case_study.pdf> [Accessed 16 February 2020].

Food and Nutrition Council (FNC), and Kembo, G. D., 2018. *Zimbabwe National Nutrition Survey - 2018*. [pdf] Available at:
<<https://www.unicef.org/zimbabwe/media/1056/file/Zimbabwe%202018%20National%20Nutrition%20Survey%20Report.pdf>> [Accessed 5 March 2020].

Gebre, A., Reddy, S.P., Mulugeta, A., Sedik, Y. and Kahssay, M., 2019. Prevalence of malnutrition and associated factors among under-five children in pastoral communities of Afar Regional State, Northeast Ethiopia: A community-based cross-sectional study. *Journal of Nutrition and Metabolism*, [e-journal] pp.1-13. <https://doi.org/10.1155/2019/9187609>

Geda, N.R., Feng, C.X., Henry, C.J., Lepnurm, R., Janzen, B. and Whiting, S.J., 2021. Multiple anthropometric and nutritional deficiencies in young children in Ethiopia: a multi-level analysis based on a nationally representative data. *BMC Pediatrics*, 21(1), pp.1-12. <https://doi.org/10.1186/s12887-020-02467-1>

Global Nutrition Report (GNR), 2018. [online] Available at:
<<https://globalnutritionreport.org/reports/global-nutrition-report-2018/>> [Accessed 5 March 2020].

Grace, K., Davenport, F., Funk, C. and Lerner, A.M., 2012. Child malnutrition and climate in Sub-Saharan Africa: An analysis of recent trends in Kenya. *Applied Geography*, [e-journal] 35(1-2), pp.405-413. <https://doi.org/10.1016/j.apgeog.2012.06.017>

Guerrant, R.L., DeBoer, M.D., Moore, S.R., Scharf, R.J. and Lima, A.A., 2013. The impoverished gut--a triple burden of diarrhoea, stunting and chronic disease. *Nature reviews. Gastroenterology and Hepatology*, [e-journal] 10(4), pp.220–229. <https://doi.org/10.1038/nrgastro.2012.239>

Hadi, H., Stoltzfus, R.J., Dibley, M.J., Moulton, L.H., West Jr, K.P., Kjolhede, C.L. and Sadjimin, T., 2000. Vitamin A supplementation selectively improves the linear growth of Indonesian preschool children: results from a randomized controlled trial. *The American Journal of Clinical Nutrition*, [e-journal] 71(2), pp.507-

513. <https://doi.org/10.1093/ajcn/71.2.507>

Hagos, S., Lunde, T., Mariam, D.H., Woldehanna, T. and Lindtjørn, B., 2014. Climate change, crop production and child under nutrition in Ethiopia; a longitudinal panel study. *BMC Public Health*, [e-journal] 14(1), p.884. <https://doi: 10.1186/1471-2458-14-884>

Hailu, B.A., Bogale, G.G. and Beyene, J., 2020. Spatial heterogeneity and factors influencing stunting and severe stunting among under-5 children in Ethiopia: spatial and multilevel analysis. *Scientific Reports*, [e-journal] 10(1), pp.1-10. <https://doi: 10.1038/s41598-020-73572-5>

Hazir, T., Akram, D.S., Nisar, Y.B., Kazmi, N., Agho, K.E., Abbasi, S., Khan, A.M. and Dibley, M.J., 2013. Determinants of suboptimal breast-feeding practices in Pakistan. *Public Health Nutrition*, 16(4), pp.659-672. <https://doi.org/10.1017/S1368980012002935>

Hoddinott, J., Alderman, H., Behrman, J.R., Haddad, L. and Horton, S., 2013. The economic rationale for investing in stunting reduction. *Maternal and Child Nutrition*, [e-journal] 9 (Suppl. 2), pp.69-82. <https://doi.org/10.1111/mcn.12080>

Horton, S., Alderman, H. and Rivera, J.A., 2008. The challenge of hunger and malnutrition. *Copenhagen Consensus*, [online] Available at: <https://www.copenhagenconsensus.com/sites/default/files/cp_hungerandmalnutritioncc08vo12.pdf> [Accessed 5 April 2020].

Horton, S., Blum, L.S., Diouf, M., Ndiaye, B., Ndoeye, F., Niang, K. and Greig, A., 2018. Delivering vitamin a supplements to children aged 6–59 months: comparing delivery through campaigns and through routine health services in Senegal. *Current Developments in Nutrition*, [e-journal] 2(4). <https://doi.org/10.1093/cdn/nzy006>

International Food Policy Research Institute (IFPRI), 2016. *Global Nutrition Report 2016: From Promise to Impact: Ending Malnutrition by 2030*. [online] Available at: <<https://globalnutritionreport.org/reports/2016-global-nutrition-report/>> [Accessed 7 March 2020].

- Irigoyen, C., 2017. Tackling Malnutrition in Zimbabwe. *Centre for Public Impact*. [online] Available at: <<https://www.centreforpublicimpact.org/case-study/tackling-malnutrition-zimbabwe/>> [Accessed 13 March 2020].
- Kairiza, T., Kembo, G., Pallegedara, A. and Macheke, L., 2020. The impact of food fortification on stunting in Zimbabwe: does gender of the household head matter? *Nutrition Journal*, [e-journal] 19(22) pp.1-12. <https://doi.org/10.1186/s12937-020-00541-z>
- Kandala, N.B., Madungu, T.P., Emina, J.B., Nzita, K.P. and Cappuccio, F.P., 2011. Malnutrition among children under the age of five in the Democratic Republic of Congo (DRC): does geographic location matter?. *BMC Public Health*, [e-journal] 11(1), pp.1-15. <https://doi.org/10.1186/1471-2458-11-261>
- Keino, S., Plasqui, G., Ettyang, G. and van den Borne, B., 2014. Determinants of stunting and overweight among young children and adolescents in Sub-Saharan Africa. *Food and Nutrition Bulletin*, [e-journal] 35(2), pp.167-178. <https://doi.org/10.1177/156482651403500203>
- Kimani-Murage, E.W., Ndedda, C., Raleigh, K. and Masibo, P., 2013. Vitamin A supplementation and stunting levels among two-year olds in Kenya: evidence from the 2008-09 Kenya Demographic and Health Survey. *International Journal of Child Health and Nutrition*, [e-journal] 1(2), pp.135-147. <https://10.9734/EJNFS/2015/20954>
- Kinyoki, D.K., Berkley, J.A., Moloney, G.M., Odundo, E.O., Kandala, N.B. and Noor, A.M., 2016. Environmental predictors of stunting among children under-five in Somalia: cross-sectional studies from 2007 to 2010. *BMC Public Health*, [e-journal] 16(1), pp.1-9. <https://10.1186/s12889-016-3320-6>
- Kiwanuka, S. N., Ekirapa, E. K., Peterson, Okui, S. O., Rahman, M. H., Peters, D. and Pariyo, G. W., 2008. Access to and Utilisation of Health Services for the Poor in Uganda: A Systematic Review of Available Evidence. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, [e-journal] 102(11), pp.1067-1074. <https://doi.org/10.1016/j.trstmh.2008.04.023>
- Kodish, S., Aburto, N., Dibari, F., Brieger, W., Agostinho, S.P. and Gittelsohn, J., 2015. Informing a behavior change communication strategy: formative research findings from the Scaling Up Nutrition movement in Mozambique. *Food and Nutrition Bulletin*, [e-journal] 36(3), pp.354-370. <https://doi.org/10.1177/0379572115598447>

- Kraak, V.I., Vandevijvere, S., Sacks, G., Brinsden, H., Hawkes, C., Barquera, S., Lobstein, T. and Swinburn, B.A., 2016. Progress achieved in restricting the marketing of high-fat, sugary and salty food and beverage products to children. *Bulletin of the World Health Organization*, [e-journal] 94(7), p.540. <https://doi.org/10.2471/BLT.15.158667>
- Kravdal, Ø. and Kodzi, I., 2011. Children's stunting in sub-Saharan Africa: Is there an externality effect of high fertility? *Demographic Research*, [e-journal] 25, pp.565-594. <https://dx.doi.org/10.1093/clinids/10.2.478>
- Kuchenbecker, J., Jordan, I., Reinbott, A., Herrmann, J., Jeremias, T., Kennedy, G., Muehlhoff, E., Mtimuni, B. and Krawinkel, M.B., 2015. Exclusive breastfeeding and its effect on growth of Malawian infants: results from a cross-sectional study. *Paediatrics and International Child Health*, [e-journal] 35(1), pp.14-23. <https://doi.org/10.1179/2046905514Y.0000000134>
- Kumar, M., Ji, B., Babaei, P., Das, P., Lappa, D., Ramakrishnan, G., Fox, T.E., Haque, R., Petri, W.A., Bäckhed, F. and Nielsen, J., 2018. Gut microbiota dysbiosis is associated with malnutrition and reduced plasma amino acid levels: Lessons from genome-scale metabolic modelling. *Metabolic Engineering*, [e-journal] 49, pp.128–142. <https://doi.org/10.1016/j.ymben.2018.07.018>
- Legg, C., 2008. *A Spatial Analysis of Child Nutrition in West Africa*. [online] Available at: <<https://www.resakss.org/sites/default/files/pdfs/a-spatial-analysis-of-child-nutrition-in-west-afri-39384.pdf>> [Accessed 5 April 2020].
- Lloyd, S.J., Kovats, R.S. and Chalabi, Z., 2011. Climate change, crop yields, and undernutrition: development of a model to quantify the impact of climate scenarios on child undernutrition. *Environmental Health Perspectives*, [e-journal] 119(12), pp.1817-1823. <https://doi.org/10.1289/ehp.1003311>
- Magadi, M.A., 2011. Household and community HIV/AIDS status and child malnutrition in sub-Saharan Africa: evidence from the demographic and health surveys. *Social Science and Medicine*, [e-journal] 73(3):436-46. <https://doi.org/10.1016/j.socscimed.2011.05.042>
- Makoka, D., 2013. *The impact of maternal education on child nutrition: evidence from Malawi, Tanzania, and Zimbabwe*. ICF International.

- Malako, B.G., Asamoah, B.O., Tadesse, M., Hussen, R. and Gebre, M.T., 2019. Stunting and anaemia among children 6–23 months old in Damot Sore district, Southern Ethiopia. *BMC Nutrition*, [e-journal] 5(1), p.3. <https://doi.org/10.1186/s40795-018-0268-1>
- Maradzika, J., Makwara, I.P. and Chipunza, S., 2016. Factors associated with stunting among children aged 0 to 59 months in Harare City, Zimbabwe. *Lifescience Global*, [e-journal] 5(1). <https://10.6000/1929-4247.2016.05.01.5>
- Marriott, B.P., White, A., Hadden, L., Davies, J.C. and Wallingford, J.C., 2012. World Health Organization (WHO) infant and young child feeding indicators: associations with growth measures in 14 low-income countries. *Maternal and Child Nutrition*, [e-journal] 8(3), pp.354-370. <https://doi.org/10.1111/j.1740-8709.2011.00380.x>
- Martin, R. M., 2001. Commentary: Does breastfeeding for longer cause children to be shorter? *International Journal of Epidemiology*, [e-journal] 30(3), 481–484. <https://doi.org/10.1093/ije/30.3.481>
- Masanja, H., Schellenberg, J.A., Mshinda, H.M., Shekar, M., Mugyabuso, J.K., Ndossi, G.D. and de Savigny, D., 2006. Vitamin A supplementation in Tanzania: the impact of a change in programmatic delivery strategy on coverage. *BMC Health Services Research*, [e-journal] 6(1), p.142. <https://doi.org/10.1186/1472-6963-6-142>
- Masarakufa, C., 2020. *Natural farming regions in Zimbabwe*. [online] Available at: <https://startupbiz.co.zw/natural-farming-regions-in-zimbabwe/> [Accessed 25 August 2020].
- Mason, J.B., Sanders, D., Musgrove, P. and Galloway, R., 2006. Community health and nutrition programs. In *Disease Control Priorities in Developing Countries. 2nd edition*. [e-book] Available at: <https://www.ncbi.nlm.nih.gov/books/NBK11726/> [Accessed 11 December 2020].
- Maximising the Quality of Scaling Up Nutrition (MQSUN), 2014. Report on Phase 1 of the Spatial Mapping of Nutrition Programming Project. [pdf] Available at: <http://www.heart-resources.org/wp-content/uploads/2015/02/Spatial-Mapping-Report-FINAL-17-11-14.pdf>.> [Accessed 7 May 2020].
- Maxwell, M., Haruzivishe, C., Zvinavashe, M. and Mukora-Mutseyekwa, F.M., 2015. Perceptions and Barriers to Exclusive Breastfeeding in Manicaland, Zimbabwe. *Journal of Public Health Medicine*, [e-journal] 21(30), pp.2422-8419. Available at:

<<https://www.researchgate.net/publication/301659225> Perceptions and Barriers to Exclusive Breastfeeding in Manicaland Zimbabwe> [Accessed 3 November 2020].

McGovern, M.E., Krishna, A., Aguayo, V.M. and Subramanian, S.V., 2017. A review of the evidence linking child stunting to economic outcomes. *International Journal of Epidemiology*, [e-journal] 46(4), 1171–1191. <https://doi.org/10.1093/ije/dyx017>

Mohammed, S.H., Habtewold, T.D., Abdi, D.D., Alizadeh, S., Larijani, B. and Esmailzadeh, A., 2020. The relationship between residential altitude and stunting: evidence from >26 000 children living in highlands and lowlands of Ethiopia. *British Journal of Nutrition*, [e-journal] 123(8), pp.934-941. <https://doi.org/10.1017/S0007114519003453>

Muchadenyika, D. and Williams, J.J., 2016. Social change: urban governance and urbanization in Zimbabwe. *Urban Forum*, [e-journal] 27(3), pp.253-274. <https://doi.org/10.1007/s12132-016-9278-8>

Muldiasman, M., Kusharisupeni, K., Laksminingsih, E., and Besral, B., 2018. Can early initiation to breastfeeding prevent stunting in 6–59 months old children? *Journal of Health Research*, [e-journal] 32(5), 334-341. <https://doi:10.1108/jhr-08-2018-038>

Mundagowa, P. T., Chadambuka, E. M., Chimberengwa, P. T., and Mukora-Mutseyekwa, F. (2019). Determinants of exclusive breastfeeding among mothers of infants aged 6 to 12 months in Gwanda district, Zimbabwe. *International Breastfeeding Journal*, [e-journal] 14(1). <https://doi:10.1186/s13006-019-0225-x>

Musisi, S. and Jacobson, S., 2015. *Brain development and dementia in Sub-Saharan Africa*. New York: Springer.

Mzumara, B., Bwembya, P., Halwiindi, H., Mugode, R. and Banda, J., 2018. Factors associated with stunting among children below five years of age in Zambia: evidence from the 2014 Zambia Demographic and Health Survey. *BMC Nutrition*, [e-journal] 4(1), p.51. <https://doi.org/10.1186/s40795-018-0260-9>

Ncube, B., Mavondo, G.A., Kandawasvika, G. and Chamisa, J.A., 2020. Elucidation of food security as a determinant of malnutrition and stunting on children under five years: A case of Insiza District, Matabeleland South, Zimbabwe. *Asian Journal of Pediatric Research*, [e-journal] 3(3), pp.11-31. <https://doi.org/10.9734/ajpr/2020/v3i330129>

Nguyen, P.H., Scott, S., Neupane, S., Tran, L.M. and Menon, P., 2019. Social, biological, and programmatic factors linking adolescent pregnancy and early childhood undernutrition: a

path analysis of India's 2016 National Family and Health Survey. *The Lancet Child and Adolescent Health*, [e-journal] 3(7), pp.463-473. [https://doi.org/10.1016/S2352-4642\(19\)30110-5](https://doi.org/10.1016/S2352-4642(19)30110-5)

Nshimiyiryo, A., Hedt-Gauthier, B., Mutaganzwa, C., Kirk, C.M., Beck, K., Ndayisaba, A., Mubiligi, J., Kateera, F. and El-Khatib, Z., 2019. Risk factors for stunting among children under five years: a cross-sectional population-based study in Rwanda using the 2015 Demographic and Health Survey. *BMC Public Health*, [e-journal] 19(175). <https://doi.org/10.1186/s12889-019-6504-z>

Olusanya, B.O., 2012. Pattern of head growth and nutritional status of microcephalic infants at early postnatal assessment in a low-income country. *Nigerian Journal of Clinical Practice*, [e-journal] 15(2), pp.142-146. Available at: <https://www.ajol.info/index.php/njcp/article/view/7881> [Accessed 8 November 2020].

Omoni, A.O., Ntozini, R., Evans, C., Prendergast, A.J., Moulton, L.H., Christian, P.S. and Humphrey, J.H., 2017. Child growth according to maternal and child HIV status in Zimbabwe. *The Paediatric Infectious Disease Journal*, [e-journal] 36(9), pp.869-876. <https://doi.org/10.1097/INF.0000000000001574>

Oot, L., Sethuraman, K., Ross, J. and Sommerfelt, A.E., 2016. The effect of chronic malnutrition (stunting) on learning ability, a measure of human capital: A model in PROFILES for country-level advocacy. *Food and Nutrition Technical Assistance*. [online] Available at: <https://www.fantaproject.org/sites/default/files/resources/PROFILES-brief-stunting-learning-Feb2016.pdf> [Accessed 12 August 2020].

Poulisse, J., and Van den Bergen, T., 2006. Fertilizer use by crop in Zimbabwe. *Food and Agriculture Organization of the United Nations (FAO)*. [online] Available at: <http://www.fao.org/3/a0395e/a0395e00.htm#Contents> [Accessed 8 November 2020].

Prendergast, A. J., and Humphrey, J. H. 2014. The Stunting Syndrome in Developing Countries. *Paediatrics and International Child Health*, [e-journal] 34(4), pp.250-265. <https://doi.org/10.1179/2046905514Y.0000000158>

Prendergast, A.J., Chasekwa, B., Evans, C., Mutasa, K., Mbuya, M.N., Stoltzfus, R.J., Smith, L.E., Majo, F.D., Tavengwa, N.V., Mutasa, B. and Mangwadu, G.T., 2019. Independent and combined effects of improved water, sanitation, and hygiene, and improved complementary feeding, on stunting and anaemia among HIV-exposed children in rural Zimbabwe: a cluster-

randomised controlled trial. *The Lancet*, [e-journal] 3(2), pp.77-90.

[https://doi.org/10.1016/S2352-4642\(18\)30340-7](https://doi.org/10.1016/S2352-4642(18)30340-7)

Raftree, L., 2019. Digital and Social Media for Social and Behaviour Change

Communication. [e-book] Editor: Nicola Harford. Available at:

<<https://imediaassociates.org/app/uploads/2019/07/Digital-and-Social-Media-for-SBCC-March-2019.pdf>> [Accessed 11 December 2020].

Rahman, M.S., Mushfiquie, M., Masud, M.S. and Howlader, T., 2019. Association between malnutrition and anaemia in under-five children and women of reproductive age: Evidence from Bangladesh Demographic and Health Survey 2011. *PloS One*, [e-journal] 14(7), p.e0219170. <https://doi.org/10.1371/journal.pone.0219170>

Raiten, D.J. and Bremer, A.A., 2020. Exploring the nutritional ecology of stunting: New approaches to an old problem. *Nutrients*, [e-journal] 12, p.371.

<https://doi.org/10.3390/nu12020371>

Reinhardt, K. and Fanzo, J., 2014. Addressing chronic malnutrition through multi-sectoral, sustainable approaches: a review of the causes and consequences. *Frontiers in Nutrition*, [e-journal] 1, p.13. <https://doi.org/10.3389/fnut.2014.00013>

Rodriguez-Morales, A.J., Bolivar-Mejía, A., Alarcón-Olave, C. and Calvo-Betancourt, L.S., 2016. Nutrition and Infection. *Encyclopedia of Food and Health*, [e-journal] pp.98-103.

Available at: <https://www.researchgate.net/figure/Nutrition-and-infection-cycle_fig1_282505596> [Accessed December 2020].

Rollins, N.C., Bhandari, N., Hajeebhoy, N., Horton, S., Lutter, C.K., Martines, J.C., Piwaz, E.G., Richter, L.M. and Victora, C.G., 2016. Breastfeeding 2: why invest, and what it will take to improve breastfeeding practices. *Lancet*, [e-journal] 387(10017), pp.491-504.

[https://doi.org/10.1016/S0140-6736\(15\)01044-2](https://doi.org/10.1016/S0140-6736(15)01044-2)

Rossa, P., 2016. *Stunting is holding back the development of South Asian children and nations*. [online] Available at: <<https://www.unicef.org/rosa/press-releases/stunting-holding-back-development-south-asian-children-and-nations>> [Accessed 26 August 2020].

Scheffler, C., Hermanussen, M., Bogin, B., Liana, D.S., Taolin, F., Cempaka, P.M.V.P., Irawan, M., Ibbibah, L.F., Mappapa, N.K., Payong, M.K.E. and Homalessy, A.V., 2020. Stunting is not a synonym of malnutrition. *European Journal of Clinical Nutrition*, 74(3), pp.377-386. <https://doi.org/10.1038/s41430-019-0439-4>

Shroff, M.R., Griffiths, P.L., Suchindran, C., Nagalla, B., Vazir, S. and Bentley, M.E., 2011. Does maternal autonomy influence feeding practices and infant growth in rural India? *Social Science and Medicine*, [e-journal] 73(3), pp.447-455.

<https://doi.org/10.1016/j.socscimed.2011.05.040>

Siekmans, K., Bégin, F., Situma, R. and Kupka, R., 2017. The potential role of micronutrient powders to improve complementary feeding practices. *Maternal and Child Nutrition*, [e-journal] 13, p.e12464. <https://doi.org/10.1111/mcn.12464>

Simler, K.R., 2006. Nutrition mapping in Tanzania: an exploratory analysis. *IFPRI Food Consumption and Nutrition Division Discussion Paper*, [online] (204). Available at : <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1288814> [Accessed 5 April 2020].

Sinharoy, S.S., Clasen, T. and Martorell, R., 2020. Air pollution and stunting: a missing link? *The Lancet Global Health*, [e-journal] 8(4), pp.e472-e475.

[https://doi.org/10.1016/S2214-109X\(20\)30063-2](https://doi.org/10.1016/S2214-109X(20)30063-2)

Smith, L.E., Prendergast, A.J., Turner, P.C., Mbuya, M.N., Mutasa, K., Kembo, G. and Stoltzfus, R.J., 2015. The potential role of mycotoxins as a contributor to stunting in the SHINE trial. *Clinical Infectious Diseases*, [e-journal] 61(Suppl_7), pp.S733-S737.

<https://doi.org/10.1093/cid/civ849>

Southern Africa Development Community (SADC), 2019. *Regional Vulnerability Assessment and Analysis Synthesis Report*. Windhoek, Namibia.

Ssentongo, P., Ba, D.M., Ssentongo, A.E., Fronterre, C., Whalen, A., Yang, Y., Ericson, J.E. and Chinchilli, V.M., 2020. Association of vitamin A deficiency with early childhood stunting in Uganda: A population-based cross-sectional study. *PLOS One*, [e-journal] 15(5), p.e0233615. <https://doi.org/10.1371/journal.pone.0233615>

Stewart, C. P., Iannotti, L., Dewey, K.G., Michaelsen, K.F. and Onyango, A.W., 2013. Contextualising complementary feeding in a broader framework for stunting prevention. *Maternal and Child Nutrition*, [e-journal] 9(Suppl 2), pp.27-45.

<https://doi.org/10.1111/mcn.12088>

Sunguya, B.F., Poudel, K.C., Mlunde, L.B., Urassa, D.P., Yasuoka, J. and Jimba, M., 2014. Poor nutrition status and associated feeding practices among HIV-positive children in a food secure region in Tanzania: a call for tailored nutrition training. *PloS One*, 9(5), p.e98308.

<https://doi.org/10.1371/journal.pone.0098308>

Syeda, B., Agho, K., Wilson, L., Maheshwari, G.K. and Raza, M.Q., 2020. Relationship between breastfeeding duration and undernutrition conditions among children aged 0–3 Years in Pakistan. *International Journal of Pediatrics and Adolescent Medicine*. 8(1), pp:10-17.

<https://doi.org/10.1016/j.ijpam.2020.01.006>

Tanjung, C., Prawitasari, T. and Sjarif, D., 2020. Comments on “Stunting is not a synonym of malnutrition.” *European Journal of Clinical Nutrition*, [e-journal] 74(3), pp.527-528.

<https://doi.org/10.1038/s41430-020-0570-2>

Tydemman-Edwards, R., Van Rooyen, F.C. and Walsh, C.M., 2018. Obesity, undernutrition and the double burden of malnutrition in the urban and rural southern Free State, South Africa. *Heliyon*, [e-journal] 4(12), pe00983. <https://doi.org/10.1016/j.heliyon.2018.e00983>

Ukwuani, F.A. and Suchindran, C.M., 2003. Implications of women's work for child nutritional status in sub-Saharan Africa: a case study of Nigeria. *Social Science and Medicine*, [e-journal] 56(10), pp.2109-2121. [https://doi.org/10.1016/S0277-9536\(02\)00205-8](https://doi.org/10.1016/S0277-9536(02)00205-8)

UNICEF, 2014. *Approach to Nutrition Programming in the East Asia and Pacific Region 2014-2025. Strategic approach and implementation guidance*. [pdf] Available at: https://www.unicef.org/Vol_1_EAPR_strategic_approach_to_nutrition_programming.pdf [Accessed 11 December 2020].

UNICEF, WHO, The World Bank Group, 2019. *Joint child malnutrition estimates - Levels and trends*. [online] Available at: <https://www.who.int/nutgrowthdb/estimates2018/en/> [Accessed 11 August 2020].

UNICEF, 2020. *Nutrition*. [online] Available at: <https://www.unicef.org/zimbabwe/nutrition> [Accessed 3 March 2020].

Vesel, L., Bahl, R., Martines, J., Penny, M., Bhandari, N. and Kirkwood B.R., 2010. Use of new World Health Organization child growth standards to assess how infant malnutrition relates to breastfeeding and mortality. *Bulletin of the World Health Organization*, [online] 88(1), pp.39-48. Available at: <https://www.who.int/bulletin/volumes/88/1/08-057901/en/> [Accessed 6 March 2020].

Victora, C.G., Adair, L., Fall, C., Hallal, P.C., Martorel, R., Richter, L., Sachdev, H.S., and the Maternal and Child Undernutrition Study Group, 2008. Maternal and Child Undernutrition 2: Consequences for Adult Health and Human Capital. *The Lancet*, [e-journal] 371, 340-357. [https://doi.org/10.1016/S0140-6736\(07\)61692-4](https://doi.org/10.1016/S0140-6736(07)61692-4)

- Vonaesch, P., Morien, E., Andrianonimiadana, L., Sanke, H., Mbecko, J.R., Huus, K.E., Naharimanananirina, T., Gondje, B.P., Nigatoloum, S.N., Vondo, S.S. and Kandou, J.E.K., 2018. Stunted childhood growth is associated with decompartmentalization of the gastrointestinal tract and overgrowth of oropharyngeal taxa. *Proceedings of the National Academy of Sciences*, 115(36), pp.E8489-E8498. <https://doi.org/10.1073/pnas.1806573115>
- Waldfoegel, J., 2002. Childcare, women's employment, and child outcomes. *Journal of Population Economics*, 15(3), pp.527-548. <https://doi.org/10.1007/s001480100072>
- WHO Expert Committee on Physical Status, 1995. *Physical status: The use and interpretation of anthropometry*. Geneva: WHO.
- WHO, 2010. *Nutrition Landscape Information System (NLIS): Country profile indicators. Interpretation guide*. [online] Available at: https://www.who.int/nutrition/nlis_interpretation_guide.pdf [Accessed 11 August 2020].
- WHO, 2013. *Childhood Stunting: Context, Causes and Consequences: WHO Conceptual Framework*. [online] Available at: https://www.who.int/nutrition/events/2013_ChildhoodStunting_colloquium_14Oct_ConceptualFramework_colour.pdf?ua=1 [Accessed 8 May 2020].
- WHO, 2014. *Global Nutrition Targets 2025: Stunting policy brief*, [online] Available at: https://apps.who.int/iris/bitstream/handle/10665/149019/WHO_NMH_NHD_14.3_eng.pdf?ua=1 [Accessed 29 April 2020].
- WHO, 2020. *Stunting in a nutshell*. [online] Available at: https://www.who.int/nutrition/healthygrowthproj_stunted_videos/en/ [Accessed 11 August 2020].
- Wicaksono, F. and Harsanti, T., 2020. Determinants of stunted children in Indonesia: A multilevel analysis at the individual, household, and community levels. *Kesmas: National Public Health Journal*, [e-journal] 15(1), pp.48-53. <http://dx.doi.org/10.21109/kesmas.v15i1.2771>
- Woldehanna, T., Behrman, J.R. and Araya, M.W., 2017. The effect of early childhood stunting on children's cognitive achievements: Evidence from young lives Ethiopia. *The Ethiopian Journal of Health Development*, [e-journal] 31(2), pp.75–84. Available at: <https://pubmed.ncbi.nlm.nih.gov/29249889/> [Accessed 5 December 2020].

Yaya, S., Oladimeji, O., Odusina, E.K. and Bishwajit, G., 2020. Household structure, maternal characteristics and children's stunting in sub-Saharan Africa: Evidence from 35 countries. *International Health*, [e-journal] <https://doi.org/10.1093/inthealth/ihz105>

Zhihui, L., Kim, R., Vollmer, S. and Subramanian, S.V., 2020. Factors associated with child stunting, wasting, and underweight in 35 low- and middle-income countries. *JAMA Network Open*, [e-journal] 3(4), p.e203386. <https://doi.org/10.1001/jamanetworkopen.2020.3386>

Zimbabwe National Statistics Agency and ICF International. 2016. *Zimbabwe Demographic and Health Survey 2015: Final Report*. [pdf] Available at: <http://dhsprogram.com/pubs/pdf/FR322/FR322.pdf> [Accessed 1 March 2020].



APPENDIX

Appendix 1: Excel data collection tool

AutoSave On Stunting prevalence data and classification - Saving... Rufaro MUSVAIRE RM

File Home Insert Page Layout Formulas Data Review View Help Search Share Comments

Clipboard Font Alignment Number Styles Cells Editing Ideas Sensitivity

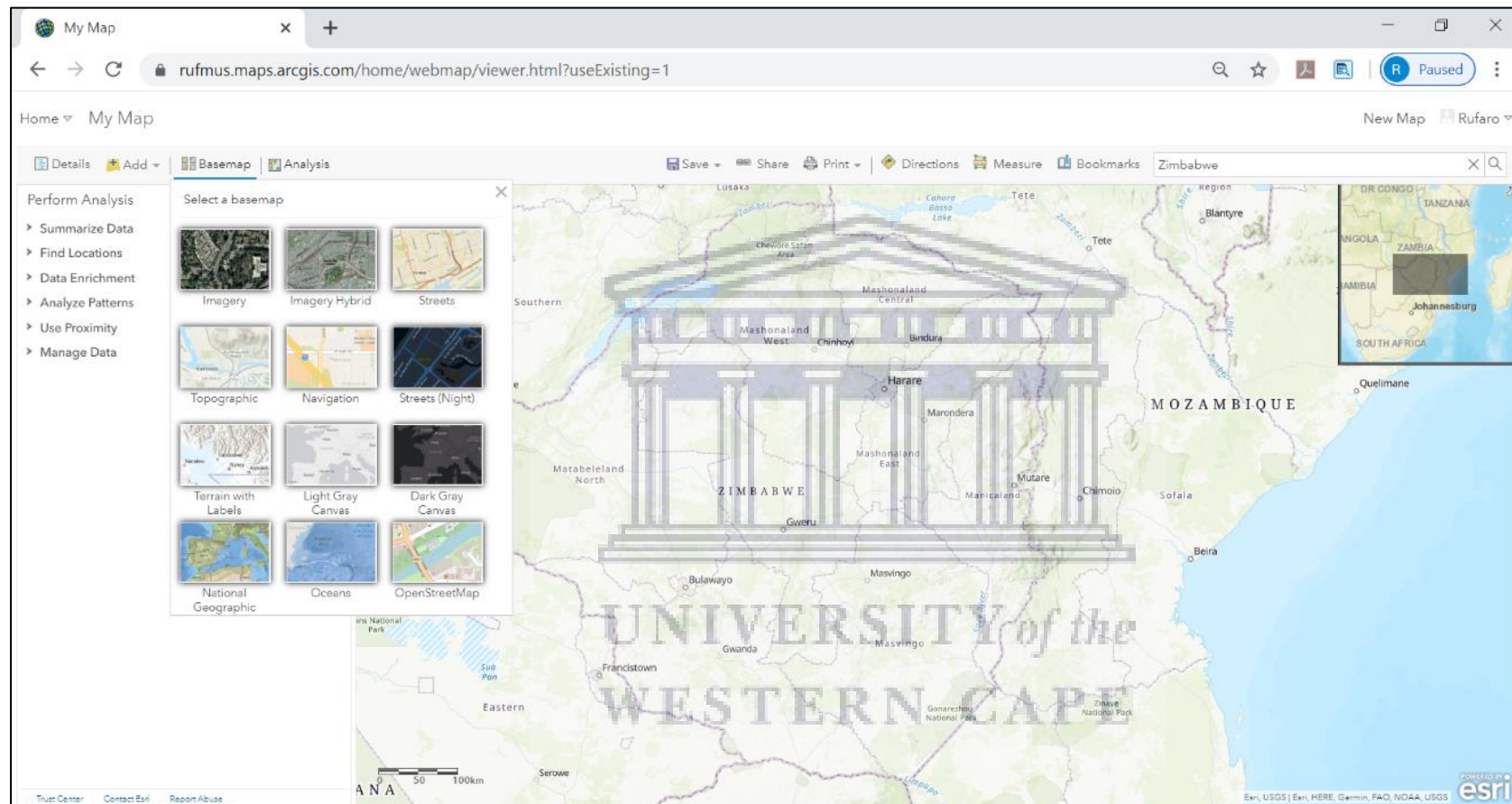
B16

Province	Stunting prevalence in children under-five	Coding as per WHO Classification
Manicaland	30,3	Very high
Mashonaland Central	28,7	High
Mashonaland East	24,5	High
Mashonaland West	27,7	High
Matabeleland North	23,5	High
Matabeleland South	31,1	Very high
Midlands	27,4	High
Masvingo	26,8	High
Harare	23	High
Bulawayo	18,8	Medium

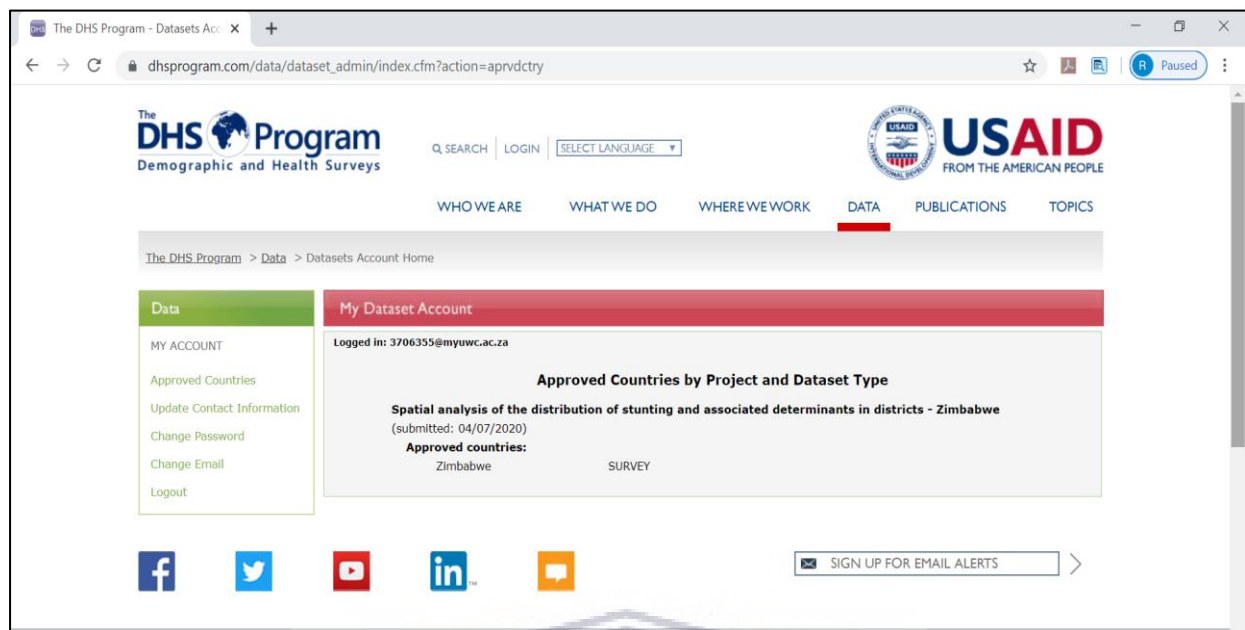
Stunting data

Ready

Appendix 2: GIS capturing tool



Appendix 3: DHS approval to access Zimbabwe Demographic Health Survey datasets



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13 August 2020

Ms R Musvaire
School of Public Health
Faculty of Community and Health Sciences

Ethics Reference Number: HS20/6/11

Project Title: Spatial analysis of the distribution of stunting and its associations with key child health and nutrition determinants at provincial level in Zimbabwe.

Approval Period: 30 July 2020 – 30 July 2023

I hereby certify that the Humanities and Social Science Research Ethics Committee of the University of the Western Cape approved the methodology and ethics of the above mentioned research project.

Any amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

Please remember to submit a progress report by 30 November each year for the duration of the project.

The permission to conduct the study must be submitted to HSSREC for record keeping purposes.

The Committee must be informed of any serious adverse event and/or termination of the study.

Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

NHREC Registration Number: HSSREC-130416-049

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