

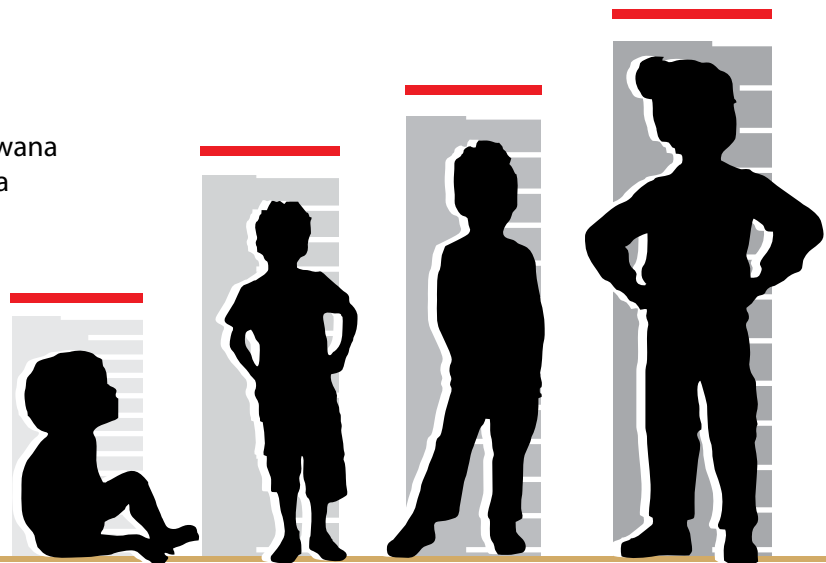
The Multi-Dimensional Risk of Stunting Amongst Children Under Five Years in Zimbabwe

Insights from Machine Learning and
Advanced Econometrics Techniques on
Population Survey Datasets

Advanced policy-focused poverty analysis in Zimbabwe

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I ABSTRACT

Background: Despite the commendable decline from a peak of 35% in 2005 (ZDHS 2005), child stunting in Zimbabwe remains high at 23.5% (MIC2019). The stunting prevalence nevertheless remains considerably lower than the sub-Saharan average of 34.1% in 2017 (WDI 2018). Despite the increasing knowledge on the patterns of stunting, a lot more is still to be established regarding the determinants of stunting in the Zimbabwe context. Global evidence and literature has provided a framework for understanding the determinants and pathways for child malnutrition.

The major causes of malnutrition include immediate ones that are anchored on the inadequate intake and utilisation of food with the right nutrient content and safe for human consumption; and the poor health status of individuals. Food insecurity, limited knowledge on diets, and sub-optimal child feeding, and care practices contribute to the inadequacy of quality food intake and utilisation. Poor health status is largely driven by limited access to health care services that have an impact on nutrition and a range of environmental factors. Although this understanding provides a sound basis for policy formulation, the extent to which these policies are translated to sound strategic actions depends to a large extent on a robust understanding of the role of the sub-components of these domains of influence and their interactions within the Zimbabwe context. This study sought to identify the key predictors of child stunting, quantify the multi-dimensional risk exposure amongst children in Zimbabwe as well as explore the interplay of stunting predictors and poverty.

Methods: In order to achieve the above, the study used Machine Learning and Artificial Intelligence techniques as the core tools of analysis. Specifically, the analysis focused on three interrelated steps: i) feature selection using Random Forest (RF) Model, ii) development of the Multi-dimensional Malnutrition Risk Index (MMRI) using selected features and iii) decomposition of the MMRI and exploratory analysis (including spatial mapping). This entailed initially selecting the most important predictor variables (feature selection) using the RF and Boruta Models, followed by using the selected features to compute a risk index, MMRI, based on a child's concurrent deprivations against these features and subsequently using the computed index scores in exploratory analysis with poverty measures.

Findings: The study reveals that child stunting in Zimbabwe is influenced by an interplay of a complex web of factors that align to the domains of health (status, behaviour, family planning and utilisation), biological, socio-economic, demographic and environmental factors as well as direct factors such as Feeding/Caregiving Practices. The extent to which children were exposed to the desired state for each of the selected predictor variables varies and the topmost common areas of deprivations are related to breastfeeding practices, child care and maternal health care utilisation. In general, the analysis shows that the drivers of child malnutrition in Zimbabwe go beyond deficiencies in food consumption to include child care and feeding practices, health related behavioral practices, access to and utilisation of quality health care, socio-economic determinants as well as poverty induced inequities.

Strengthening the multi-sectoral approach and adopting a data driven response strategies including for geographical targeting of nutrition specific interventions and adaptive learning will be essential to enhance the current efforts in the national response.

2 BACKGROUND

Zimbabwe has made notable strides in improving key health outcomes following collective efforts and investments in select high impact interventions in the last eight years, but the progress has been slow. Key indicators continue to fare poorly with respect to progress against milestone targets despite the indications of positive change. Recent national surveys have confirmed the positive trajectory. The Multiple Indicator Cluster Survey (MICS) of 2019 estimated the maternal mortality ratio at 462 maternal deaths per 100,000 live births pointing to a continued reduction from the MICS 2014 estimate of 614 maternal deaths per 100,000 live births. The 2019 estimate, however, remains much high relative to the 2015 target of 300 maternal deaths per 100,000 live births. Under-5 mortality is currently at 69 deaths per 1,000 births and neonatal mortality has increased from 29 deaths per 1,000 live births in 2015 to 32 deaths per 1,000 live births in 2019 (MICS 2019). Table 1 provides an outline of the status of key health indicators in Zimbabwe.

Table 1: Status of Key Health Outcomes in Zimbabwe

Indicator	Measure and Source	ZDHS 2010-11	ZDHS 2015-16	MICS 2019 /Other
Maternal Mortality Ratio	Maternal Deaths per 100,000 Live Births	960	651	462
U5 Mortality	Deaths per 1,000 Live Births	84	69	65
Neonatal Mortality				
	Deaths per 1,000 Live Births	31	29	32
Stunting for Children U5	Prevalence (%)	32%	27%	23.5%
Adolescent Fertility Rate ¹	Live Births per 1,000 Adolescent Women	115	110	108
Teenage Pregnancy Rate ²	Prevalence (%)	24%	22%	
Family Planning (FP) Coverage	Population Coverage (%)	59%	67%	68%
Unmet FP Needs	Prevalence (%)	13%	10%	8%
Adult HIV Prevalence	Prevalence (%)	15.2%	13.8%	12.7%
Malaria Incidence	Incidence Per 1,000 Population		29	19

¹ Number of live births to women aged 15 to 19 per 1,000 women aged 15 to 19.

² Proportion of pregnant women aged 15 to 19 per 1,000 women aged 15 to 19.

The slow progress is largely attributed to the protracted exposure to economic difficulties that started from the early 2000s and peaked in 2007/2008, which left the country in a low-income food-deficit status and led to a decline in key human development indicators. Zimbabwe ranked 156th of 189 countries in the 2018 Human Development Index (HDI) and 107th of 119 countries in the 2018 Global Hunger Index. Life expectancy at birth estimated at 61.7 years, the expected and average years of schooling at 10.3 and 8.1 years respectively as well as the estimate of the Gross National Income (GNI) per capita of \$1,683 contributed to the HDI ranking. The 2019 Mini-PICES showed that in 2019 an estimated 57 percent of Zimbabweans were living below the poverty line, with 38 percent in extreme poverty. The latter marks an 8-percentage increase from the 2017 estimate of households living in extreme poverty. In rural areas, 51 percent of the population is extremely poor, and 72 percent is poor, compared with 28 percent poor in urban areas.³ Although gender inequalities have decreased, they remain significant in some sectors; the 2018 Human Development Report gives a Gender Inequality Index of 0.534, placing Zimbabwe 128th of 189. Most sectors of the Government were severely weakened and have remained constraint as a result of the protracted economic crisis. The health sector, in particular, suffered from out-migration of skilled personnel and inadequate investments in pharmaceuticals and infrastructure, which led to a sharp decline in key health outcomes in the early years of this last decade.

Nutrition indicators have not been spared as child stunting in Zimbabwe remains high at 23.5% (MIC2019) despite the commendable decline from a peak of 35% in 2005 (ZDHS 2005). The stunting prevalence nevertheless remains considerably lower than the sub-Saharan average of 34.1% in 2017 (WDI 2018). Despite the increasing knowledge on the patterns of stunting, a lot more is still to be established regarding the determinants of stunting in the Zimbabwe context. Global evidence and literature has provided a framework for understanding the determinants and pathways for child malnutrition. The major causes of malnutrition include immediate causes that are anchored on the inadequate intake and utilisation of food with the right nutrient content and safe for human consumption; and the poor health status of individuals. Food insecurity, limited knowledge on diets, and sub-optimal child feeding, and care practices contribute to the inadequacy of quality food intake and utilisation. Poor health status is largely driven by limited access to health care services that have an impact on nutrition and a range of environmental factors. Child stunting is a key contributor to the Human Capital Index (HCI) - a measure of the amount of human capital that a child born today can expect to attain by age 18 given the risks of poor health and poor education that prevail in the country where s/he lives.

Although the Malnutrition Framework has provided a sound basis for policy formulation, the extent to which these policies are translated to sound strategic actions depends to a large extent on a robust understanding of the role of the

³ 2019 Mini-PICES Report, ZIMSTAT

sub-components of these domains of influence and their interactions within the Zimbabwe context. Local data and experiences have not been fully utilized to provide a comprehensive understanding of the determinants and their interaction at a local level. Whilst previous analysis of survey data in Zimbabwe has shown some demographic and geographic variations of stunting in the country over years, an outline of the important determinants and variations in the exposure to these amongst households in Zimbabwe has not been fully documented. Additional knowledge on the determinants of stunting in the local context, therefore, remains a key priority for refining efforts to accelerate progress against the backdrop of constrained resources.

3 METHODOLOGY

The study aimed to identify the key predictors of child stunting and quantify the multi-dimensional risk exposure amongst children in Zimbabwe. The analysis sought to answer the following policy questions:

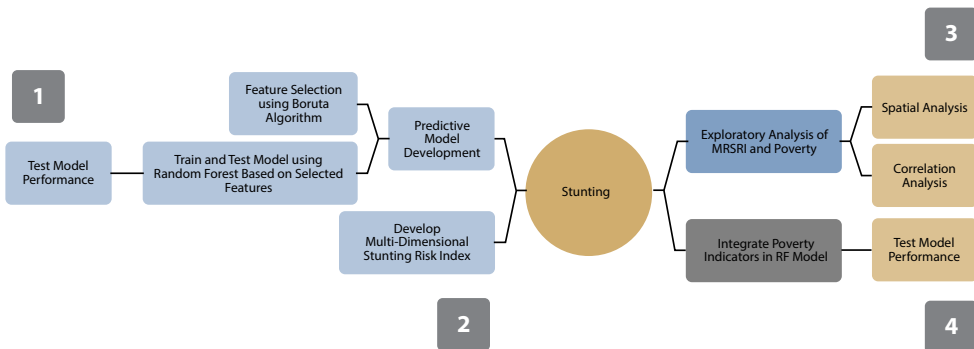
1. What is the nature and extent of interplay between demographic, environmental, social, economic and health related factors that predispose households to the increased risks of child stunting in Zimbabwe?
2. What are the priority target interventions to be considered in constituting a package of response strategies to address inequities in child stunting in Zimbabwe?
3. What is the geographical distribution of hotspots of the risk of child stunting in Zimbabwe?

This brief, therefore, aims to provide an overview of findings and key policy considerations drawn from an analysis of the determinants of stunting in Zimbabwe. The analysis sought to identify the key predictors of child stunting, quantify the multi-dimensional risk exposure amongst children in Zimbabwe as well as explore the interplay of stunting predictors and poverty. In order to achieve the above, the study used Machine Learning and Artificial Intelligence techniques as the core tools of analysis. Specifically, the analysis focused on three interrelated steps that entailed the following:

- I. Initially selecting the most important predictor variables (feature selection) using Machine Learning Techniques (Random Forest and Boruta Models), followed by;
- II. Using the selected features to compute a risk index, MMRI, based on a child's concurrent deprivations against these features and subsequently
- III. Using the computed index scores in exploratory analysis with poverty measures.

The analysis was based on data obtained from over 31,000 children assessed in the 2018 Zimbabwe National Nutrition Survey (NNS 2018) and household poverty estimates from the 2017 Poverty Income and Consumption Expenditure Survey (PICES). Figure 1 provides a summary of the steps undertaken in the analysis.

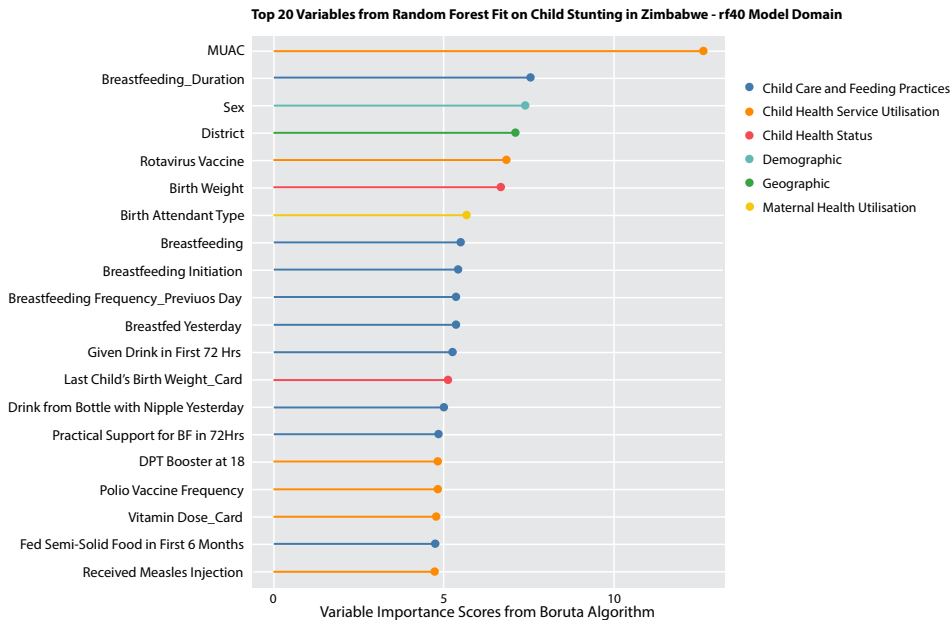
Figure 1. Steps in Analysis



Findings: Predictors, Determinants and Drivers of Stunting

Child stunting in Zimbabwe is influenced by a complex web of factors that align to the domains of health (status, behaviour, family planning and utilisation), biological, socio-economic, demographic and environmental factors as well as direct factors such as Feeding/Caregiving Practices. The analysis showed that status of the child's growth based on the Mid-Upper Arm Circumference (MUAC) measurement is the top predictor, which is not surprising but remains critical given the already adopted role of growth monitoring in the nutrition response. Other predictors that ranked high include the sex of the child, the District of stay therefore confirming heterogeneity, child status at birth, skilled birth attendance and breastfeeding practices (Figure 2). Although Figure 2 is illustrative of only the top 20 predictor variables, the full listing of the confirmed predictors against their domains validates the continued relevance of the UNICEF Malnutrition Framework. The ranking signifies the varying levels of influence of the different domains and sub-indicators to stunting occurrence in Zimbabwe.

Figure 2: Top Predictors of Stunting in Zimbabwe



Isolating the determinants⁴ from this list of predictors shows that dominant features in driving stunting in Zimbabwe reflect the need to prioritize child care feeding practices, utilisation of child care services including immunization and strengthening maternal health services including the health of the mother. Food consumption and dietary diversity are important considerations in understanding the prevalence of stunting in Zimbabwe.

The lower ranking in prediction for water and sanitation related indicators is consistent with local and regional evidence. Several studies have shown limited impact of improved WASH on stunting reduction. The Sanitation, Hygiene, Infant Nutrition Efficacy (SHINE) Randomised Control Trial (RCT) conducted in Zimbabwe found infant nutrition to have more effect on reducing stunting prevalence compared to provision of WASH. The World Bank report - *Reducing Stunting Through Multi-Sectoral Efforts In Sub-Saharan Africa: All Hands On Deck*, showed geographical variations in the association of WASH and malnutrition. The report notes that access to WASH associated with lower probabilities of stunting in only four of the 33 Sub-Saharan Africa countries included in the analysis – Gabon, Guinea, Lesotho and Uganda. In this study, main water source and type of sanitation facility were predictors of stunting. Although they are weaker predictors

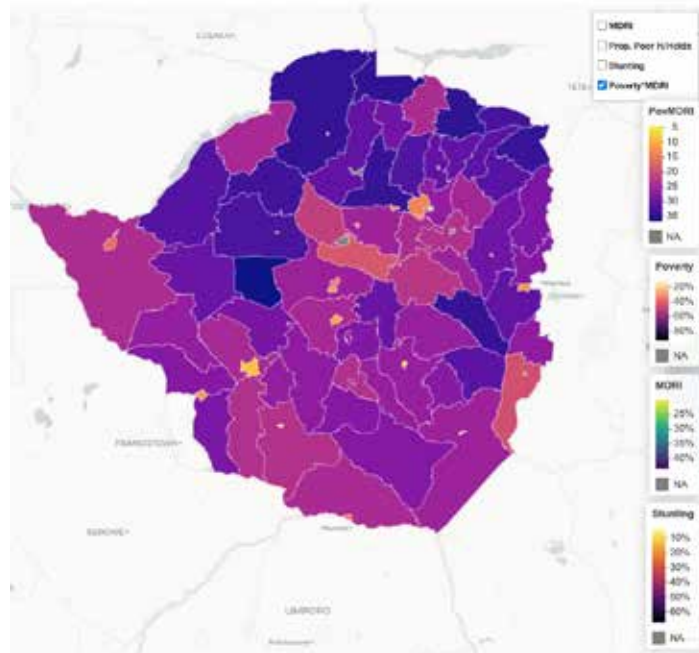
⁴ Note that variables such as Sex and District are predictors but not necessarily regarded as drivers or determinants as they only foretell the state but do not determine

compared to other indicators such as childcare, feeding practices and health services utilization, it is critical to note that improved WASH plays an important role in interrupting pathways for contamination of the environment and thus systematically prevent human exposure to pathogens. This will in turn reduce episodes of poor WASH-related infections thereby promoting healthy growth in children.

The assessment of the extent to which children were exposed to the desired state for each of the selected determinants shows that the top most common areas of deprivations are related to breastfeeding practices, child care and maternal health care utilisation. Furthermore, the index developed to quantify the concurrent occurrence of the deprivations is higher amongst children that are stunted therefore confirming the multi-dimensional nature of the risks of stunting (Table 2). The extent of exposure of children to this multidimensional risk also varies across districts (Figure 3), in line with the spatial patterns for stunting when taking into account dimensions of poverty.

Table 2: Intensity of Exposure to Risk and Multi-Dimensional Risk Index

Group	Metric	Coefficient	Error	95% CI - LB	95% CI - UB
Overall	H - Intensity of Exposure	0.148	0.002	0.144	0.152
	Mo - Multi-Dimension Risk Index	0.079	0.001	0.077	0.081
Stunted	H - Intensity of Exposure	0.162	0.004	0.155	0.169
	Mo - Multi-Dimension Risk Index	0.086	0.002	0.083	0.09
Not Stunted	H - Intensity of Exposure	0.142	0.002	0.138	0.147
	Mo - Multi-Dimension Risk Index	0.075	0.001	0.073	0.078

Figure 3 Spatial Patterns of Poverty-Weighted Multi-Dimensional Risk Index (MDRI)

The interplay between poverty, food security and the multi-dimensional risk of deprivation to the stunting determinants additionally provides useful insights regarding the role of household poverty as a contributor to stunting. Previous studies have shown that poverty presents complex dynamics at household level that not only affect food security but access to appropriate dietary diversity and utilisation of essential services, such as maternal health services, that are linked to the established determinants of stunting.

The findings from the analysis broadly show that, child malnutrition in Zimbabwe is driven by a range of factors that go beyond deficiencies in food consumption to include health related behavioral practices, access to and utilisation of quality health care, socio-economic determinants as well as poverty induced inequities. Despite having lowly positioned predictors, the WASH domain remains important due to the pathways (e.g diarrhoea, anaemia, gut health) influencing some of the identified high-ranking predictors. In that regard,

scaling coverage of WASH services in communities and having context-specific interventions remains important. Multiple exposures to these determinants further compound the risk of stunting in children. An effective national response to the stunting burden calls for a multi-sectoral approach and targeted interventions that aim to reduce exposure and break the complex linkages across these factors.

The outputs for this analysis are accessible on: https://devintel.shinyapps.io/Stunting_AI_RF/

Policy and Strategic Considerations Going Forward

Zimbabwe has made good progress in establishing the appropriate policy environment to facilitate a national response to malnutrition in the country but a number of inhibitors to the response have, however, been noted. These include the recent climatic and pandemic shocks that have compounded the already vulnerable health service delivery system owing to the protracted macro-economic challenges.

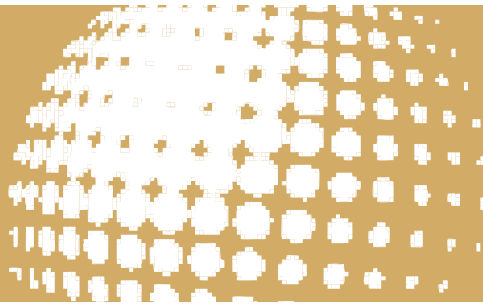
The following key considerations are proffered in view of the evidence on the determinants of stunting and recognizing the operational and policy related bottlenecks in the response.

The programmatic response to the malnutrition burden should prioritize the continued provision of high impact nutrition interventions that aim to improve access and uptake of services noted to reduce stunting in children. There are opportunities to leverage on already existing approaches such as the Results Based Financing (RBF) and Community Based Management of Acute Malnutrition (CBMAM) in terms of structure, systems and lessons learnt. New ambitious higher service levels of safely managed water and sanitation services are required in order to interrupt the pathways that link WASH to nutrition (e.g diarrhoea, anaemia, gut health). This calls for scaling the coverage of WASH services in communities and formulating context-specific WASH interventions.

The evidence supports adopting a sequenced geographical targeting approach for nutrition focused financing/investments and program implementation; that recognizes the current stunting burden with potential for scale-up in line with the varying intensity of stunting risk across the country.

Apart from a sequenced geographical targeting approach for nutrition focused financing/investments and program implementation, the multi-dimensional nature of the risks of stunting including the association with poverty underpins the need for a multi-sectoral response. Furthermore, improving investments in nutrition specific interventions and efficiently allocating these in line with local needs provides a huge opportunity to accelerate the decline in stunting prevalence. Added to that, it will be strategic for Government and stakeholders to consider leveraging on advancements in technology to strengthen data driven targeting and adaptive learning from implementation to enhance effectiveness and efficiencies in the response.

Lastly, in order to facilitate the realisation of the optimal use of data for decision making in the national response, it will be important to invest appropriately in relevant Information Systems as well as policies for data access, privacy.



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