UNIVERSITY of RWANDA

COLLEGE OF MEDICINE AND HEALTH SCIENCES

Comparative Study of Factors Associated with Stunting Among Children Under Five Years of Age in Rwanda Using RDHS 2014/2015 and 2019/2020

A research report submitted in partial fulfillment for the award of Master of Public Health in the School of Public Health,

College of Medicine and Health Sciences

By

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Abbreviation and Acronyms

CFSVA: Comprehensive Food Security & Vulnerability Analysis

CMHS: College of Medicine and Health Science

DHS: Demographic and Health Survey

DRC: Democratic Republic of Congo

EBLL: Elevated blood lead level

EED: environmental enteric dysfunction

GoR: Government of Rwanda

HAZ: Height for age z-scores

HHs: Households

RDHS: Rwanda Demographic and Health Survey

SD: Standard Deviation

SDGs: Sustainable Development Goals

SPH: School of Public Health

SSA: Sub-Saharan Africa

UN: United Nations

UR: University of Rwanda,

WASH: water, sanitation, and hygiene

WHO: Word Health Organization

Declaration

I, Gervais BAZIGA declare that this dissertation is my own work except where specifically acknowledged, and it has been passed through the anti-plagiarism system and found to be compliant and this is the approved final version.

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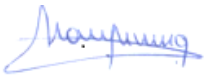
Signed: 

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MAY GOD BLESS YOU ALL!

Dedication

To Almighty God who always brightens all my paths,

My beloved late father, my precious mother who since my childhood wished and did all they could do for my bright future,

My beloved Wife, our Son and Daughters, who always encouraged me and have been my source of inspiration and strengths,

My sisters and brothers who always wished me to achieving this step

This work is wholeheartedly dedicated to you.

Abstract

Background

The WHO indicates that in 2020 more than one in five (22%) children aged below five years worldwide were stunted. The last RDHS report of 2019/2020 indicated that stunting in kids under five years was at 33%. The present study intends to compare the level of stunting in children aged 5 years and below with consideration of factors contributing to stunting in RDHS 2014/2015 and 2019/2020.

Methodology

This is a cross-sectional retrospective study design that used RDHS 2014/2015 and 2019/2020 data to contrast stunting prevalence and the factors that are influencing it. To achieve this objective, the descriptive analysis using tables and graphs, the bivariate analysis using chi-square and multivariable analysis using multiple logistic regression were performed to achieve the study objectives. All statistical tests performed at five percent significance level. All tasks related to the analysis of data were performed with Stata version 13.

Results

This study indicates that 37.85% of children were stunted in 2015, whereas 33.45% were stunted in 2020.The determinants of stunting among children under age of five years in Rwanda in 2014/15 and 2019/2020 were the child sex (female versus male) (OR<1, P-value<0.001), child age (older children versus infant less than 6 months) (OR>4, P-value<0.001), the birth weight (low versus normal weight) (OR>2, P-value<0.001), and the wealth index (all categories versus the poorest) (OR<1, P-value<0.02).

Conclusion

Stunting among under five children in Rwanda was 37.85% for RDHS 2014/2015 and 33.45% for RDHS 2019/2020; Findings indicated an role of individual and household linked predictors that include sex of the child, child's age, birth weight and wealth index as predictors of stunting. Interventions to prevent low birth weight, improve complementary feeding practices and reduce poverty are needed.

Key word: Stunting; Malnutrition, Children, Demographic Health Survey

CHAPTER I: INTRODUCTION

1.1. Definition of Key Concepts

1.1.1. Malnutrition

Malnutrition is defined as a dietary energy or nutrient deficit, excess, or imbalance. Malnutrition refers undernutrition that manifests itself as low height for age (stunting), low weight for height (wasting), low weight for age (underweight), and deficiencies of micronutrients such as vitamins and minerals. Obesity and overweight are two other types of malnutrition (1).

1.1.2 Stunting

Stunting is referred to as short height compared to age of a person (1). According to the WHO child growth standards median, it is measured as height for age minus two standard deviations (2).

1. 1.3. Demographic and Health Survey (DHS)

The DHS is a national survey that gather, evaluate, and disseminate demographic and health information. DHS collects data to estimate current fertility, death, and migration rates, as well as the factors that influence them. It contributes to the development of strategies as well as the follow-up of government and private health activities and research (4).

The existing two kinds of DHS surveys are defined below (3):

- **Standard Demographic Health Survey:** They do have big sample sizes (generally between five thousand and thirty thousand HHs households) and are carried out each five years for comparisons across period of time.
- **Interim Demographic Health Survey:** focuses on gathering data on essential indicators, although data for all impact evaluation metrics may not be included (such Malaria Indicator Survey,). Between rounds of DHS surveys, these surveys are conducted with smaller questions than the usual DHS surveys. In comparison to conventional DHS surveys, these surveys feature small samples, despite being nationally representative.

1.2 Background

The WHO indicates that, in 2020, 22 %, or more than one in five children aged below five years worldwide had stunting. However, from 2000 to 2020, the global stunting prevalence globally decreased 11.1 %, and the affected children declined 54.6 million (4). Thus, There is a global effort to reduce the nutritional deficit, but still, a large number of children of that age are suffering from the same fate(5).

In 2016, it was estimated that stunting would affect 22.9 % of the world population (6) equivalent to 154.8 million with 21.9 % (149 million) that would be kids below five years in 2018(7). Africa and Asia had the most stunted kids, accounting for eighty-seven million and fifty-nine million of the global weight of stunting in children, respectively. This indicates that progress toward the World Health Assembly's 2025 target and the 2030 SDGs (7). According to the United Nations (UN) report on the level and trends of malnutrition among under five children, among the seven sub-regions of the world, North America has the lowest prevalence for stunting with 2.6%, while Oceania has the maximum prevalence of stunting with 38.4%. In Africa, the northern region had the lowest percentage at 17.6%, and the parts of eastern Africa where Rwanda is located had the highest stunting prevalence of 35.2%(8).

The stunted children may suffer from a severe and irreversible cognitive damage that goes along with stunting (7). Stunting increases morbidity and is associated with decreased thinking in children (9), poor school achievement, reduced productivity in adulthood and an elevated incidence of NCDs among adults (10). It is also a symptom of chronic undernourishment that shows the inability to absorb adequate nutrients over a long period. The most straight causes including : not eating diversified food with carbohydrates, proteins and fruits or greens , or not eating enough food at all, food that lacks growth-triggering nutrients, and recurrent diseases that hinders the intake, absorption or use of nutrients(11).

Many studies have been done to address this global public health problem(12)(13). A metanalysis study carried in Sub-Saharan Africa revealed prevalence of stunting was associated to socioeconomic, demographic, and environmental variables. Male children and those residing in rural places were shown to be more likely to bear consequences from stunting in that study.

Additionally, to the maternal and household traits including the height of the mother , age, and education, big size of the household, and lower socio-economic position, indicators of socio-demographic and economic status such as the mother's education, mother's work, and family income were directly linked to stunting (16). A study conducted in Tanzania found that education, maternal age at birth, water availability, and other variables were identified as potential causes of stunting(14). A study of children aged below 5 years attending two malnutrition clinics in northwestern Nigeria found that about 82.8 %(15) of them were stunted compared to 79% in Niger (16). In this group, stunting was connected with being between the ages of 12 and 35 months, being male, and attending a rural malnutrition clinic. Furthermore, it was estimated that approximately 0.5% of all Nigerian children under 7 years were stunted (17). In Ethiopia, a study conducted on predictor of stunting reported that child age, child's immunization, household size, mother and partner's education and occupation, were related to children malnutrition of for those with age below 5 years(18). In Uganda, a study conducted in Karamoja among admitted children, reported that nearly 50 % of children in the study had combined wasted and stunted malnutrition(19).

In Rwanda, the recent DHS report 2019/2020 indicated that stunting among under five was estimated to be at 33%, and about 9 % had a severe stunting(11). The proportion of stunted children was greater among rural villages (36%) than urban areas (20%) (11). The Northern province had a large number (41%), the Western province was second with 40%, both of which were stunted than children in other provinces and the city of Kigali(11). The same as in other countries, the stunting in Rwanda is associated to the mother's education. The children of women without formal education were having lower height for age as compared to those whose mothers attended school(11). Looking at family wealth index, about 49% stunted children were of the lowest wealth index compared to 11% of the higher level of wealth index. Other findings assessing the same problem has reported that , basic health conditions and family structure were identified as important indicators of nutritional deficit in children under 5 years (20). There are factors such as gender, major source of food, disposal of children stool, acute respiratory infection and birthweight were found to be associated with stunting in other countries (21)Furthermore, despite the efforts put in place by the government of Rwanda, the stunting for children under five years still persists mostly in rural areas. This suggests that a study be conducted to find out the trend of stunting in

Rwanda from 2015 to 2020, as well as investigate factors associated with stunting in Rwanda during the same time period for the public information, policymakers, and other researchers about the level and burden of stunting among children under5 or younger in Rwanda.

1.3. Problem statement

This points to the need for a study to determine the trend of stunting in Rwanda between 2015 and 2020, as well as to find out factors leading to stunting in Rwanda during the same time period, in order to inform the public, policymakers, and other researchers about the level and burden of stunting in children of five years or younger in Rwanda (22). In 2020, 33% children below 5 years had stunting, with ten percent that were highly stunted (< -3 SD) (23).

The most controversial fact with the stunting was a small change (5%) between both surveys despite efforts put in place by the Government of Rwanda (GoR) and national and international partners. Thus, stunting is a top issue for Rwanda's government, which is addressing it through the SDGs. The Government is taking steps to reverse the trend by mobilizing key stakeholders. (24). (25)

Stunting can be caused by a lack of proper dietary quantity and quality, frequent illnesses, poor mother and child care habits, inadequate health access to services, and adverse factors that affect their capacity to consume food and absorb nutrients. These causes may also be different or persistent between the RDHS 2014/2015 and RDHS 2019/2020. Moreover, it was found that there was a decrease in the level of stunting between 2014 and 2020. However, the level is still high. Thus, there is a need to assess how the decrease would be speeded up for the next years to achieve SDGs target (Target 2.2: “End all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons”(25)). To our knowledge, there are no other studies that have explored stunting in the under-five age group by comparing the level of stunting and factors associated with it using the current RDHS of 2019/2020 and the previous one of 2014/2015. Therefore, we compared the stunting prevalence of both RDHSs, and factors associated with each one and the discrepancy between them. For that reason, the knowledge of the stunting distribution across the demographic characteristics of child and the household and the factors associated with it for both RDHSs can give a great contribution.

Therefore, the current study compared prevalence from both surveys and related factors to inform decision maker and the scientific community.

1.4. Questions of Research

This study responded to the questions below:

1. What is the prevalence of stunting for children below the age of 5 years in RDHS 2014/2015 and RDHS 2019/2020 data?
2. What are the factors contributive to stunting for children under five years in RDHS 2014/2015 and RDHS 2019/2020 data?

1.5. Objectives

1.5.1. Main objective

The aim of this research work was to explore Rwanda Demographic and Health Survey (RDHS) data, assess, compare and analyze the prevalence of low height for age in children of under 5 years and the factors influencing stunting in RDHS 2014/2015 and 2019/2020.

1.5.2. Specific objectives

1. To evaluate and compare prevalence of stunting between RDHS 2014/2015 and 2019/2020.
2. To analyze and compare the factors influencing stunting among kids below 5 years of age in RDHS 2014/2015 and RDHS 2019/2020 data.

1.6. Literature Review

Undernutrition remains a serious public health issue, contributing to the worldwide problem of childhood mortality and morbidity. It is responsible for 45 percent of all deaths in children under the age of five. Every year, malnutrition kills over two million across the world. Malnutrition is primarily indicated by stunting. It is explained as HAZ (height for age z-scores) less than or equal to 2 standard deviations from standard median when compared to a reference standard (26).

Stunting is a sign of growth retardation, which has long-term implications for growth and child development, as well as adult work capacity. If current trends continue, stuntin SSA is belived to rise by 2025. Stunting is most prevalent in African children during the supplemental feeding stage, when children are no longer exclusively breastfed and illnesses become more common (27).
Around 8000 children as young of five are stunted in Rwanda. The likelihood that a child will be stunted increases with age. Stunting affects more than 18% of infants between the ages of 6 and 8 months, but it jumps to a startling 49% of kids between the ages of 18 and 23 months. Boys are more at risk for stunting than girls, and children living in extremely low-income or rural areas are more likely to be suffering. (28).

1.6.1. Causes and manifestation of Stunting

Poor nutrition, recurring infections, and a lack of psychosocial stimulation all contribute to stunting. It is a primary indicator of malnutrition and infections such as diarrhea, helminthiasis in early childhood, and fetal malnutrition caused by an undernourished mother (29), the additional foods given to the child in addition to breast milk, which are frequently deficient in nutrients and energy and thus have a negative impact on growth Stunting is caused by hazardous maternal exposure up to two years of childhood as a result of poor nutrition, hygiene, and healthcare (30).

Stunting causes may also include time-based determinants of malnutrition for a child, such as motherly nutritional situation and fetal development. Child stunting appears to be caused by maternal nutritional status and food intake. The mother's mid-upper arm circumference indicated an association with stunting. The frequency of diarrhea was linked to child stunting. Additionally, the children receiving vitamin A supplement are protected from stunting as a half as compared to other children without that supplement. Similarly, the number of antenatal visits was also linked to stunting in children under five years (31). The environmental factors may also cause the stunting in children. It was found that mycotoxins from food, lack of sanitation, dirty homes, inadequate cooking stuffs, and insufficient waste management were all linked to an elevated risk of childhood stunting (32). With poor success in many places in reducing stunting and the awareness that a considerable proportion of stunting is not due to insufficient food or diarrhea alone, other variables must be at play. The environmental enteric dysfunction (EED), is a digestive inflammation that can affect newborns in impoverished countries and is thought to be a link between inadequate sanitation and stunting. Because EED has numerous causative pathways, traditional hygiene, safe

water and sanitation, interventions were limited in scope and sensitivity (33). Furthermore, Elevated blood lead level was revealed significantly as predictor of stunting. The chronic lead poisoning is significantly associated with a substantial level of stunting in child under five years of who live in slums (34).

Stunting signs can be pathologic, mental, or physiological. It was discovered that stunting at the age of one year significantly reduces cognitive and learning capacities at the ages of five, eight, twelve, and fifteen years (35). It has been established that poor dental health is linked to stunted growth. Children with developmental delays had a high orthodontic plaque index (OPI). Growth retarded children had lower saliva composition. A link of growth delay to salivary quantity and flow was also discovered. Stunting was discovered to be linked to dental problems(36). The General physical examination of stunted children, revealed a generalized physical and mental weakness, recurrent infection and anemia (37).

1.6.2. Stunting in Rwanda

The level of stunting in kid below the age of five in Rwanda remained stable between 2000 and 2010, but showed a national decay from 47.4 % in 2000 to 38.3 % in 2015 (38). Stunting increased with age, peaking at 40% among children aged 24-35 months, according to the RDHS 2019/2020, and stunting between children under five years has gradually dropped from 38% to 33% (23).
This finding was similarly found by a study carried out in Northern province among a sample of 145 children. This found a stunting prevalence of 42 % among children aged 30 months or below (39,40). According to RDHS 2019/2020 (key indicators report), the stunting was detected in a high percentage of young individuals in rural (36%) than in urban places (20%). The Northern province had the highest percentage (41%) and the Western province had the second highest percentage (40%) of stunted children, both of which were more probable than children in other provinces and the city of Kigali (11). Stunting in Rwanda is linked to the mother's educational level, as it is in other nations. Children whose mothers were illiterate were more stunted than children whose mothers had gone to school (11). In terms of family wealth index, 49 percent of stunted children had the lowest wealth index, while 11 percent had the highest wealth index. Basic health circumstances and family structure were identified as major markers of nutritional deficit in children under the age of five, according to other studies examining the same problem (20). Author et al found that factors such as gender, major source of food, disposal of children stool,

acute respiratory infection and birthweight are associated with stunting in the country (21). Furthermore, despite the efforts put in place by the government of Rwanda, the childhood stunting for children of five years and below are still persists mostly in rural areas of the country.

1.6.3. Conceptual framework

The conceptual framework describes the possible association between the outcome variable and the independent factors that are grouped into: individual characteristics, social factors, education factors, economic factors and life style. It is theorized that stunting, the outcome variable for this study is influenced by each variable from the mentioned groups in Figure 1 below. Thus, the variables listed in the figure below will be considered to exhibit a significant positive influence if they are likely to increase the risk of low height for age of children (if the linked p-value is below 5%), otherwise the influence will be considered as negative (under similar conditions).

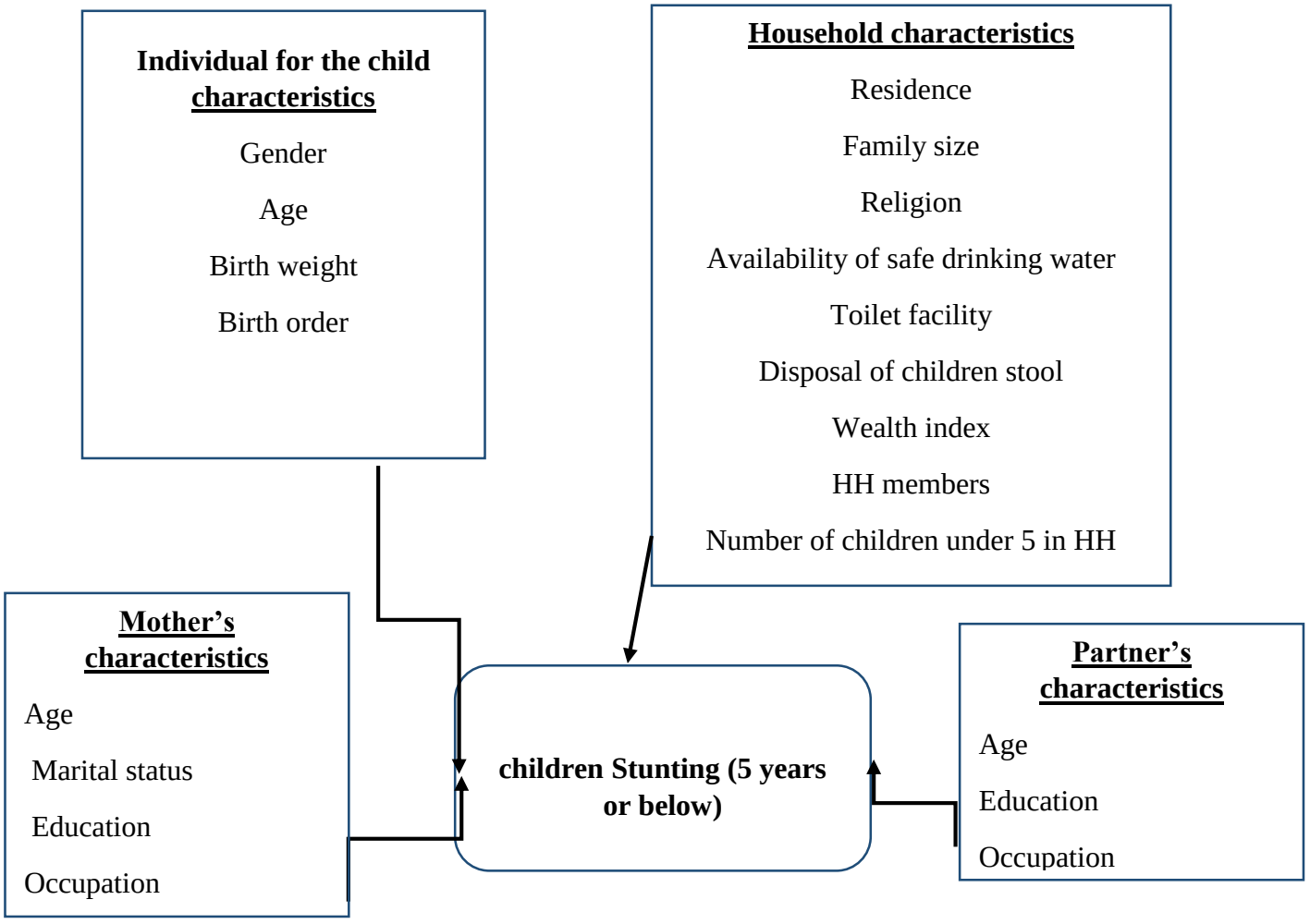

Figure 1: Conceptual framework

CHAPTER II: METHODS

2.1. Study setting description

Rwanda is a landlocked country in situated in East Africa that shares borders with Uganda in the north, Tanzania to east, DRCto the west, and Burundi in south. Kigali, the capital, is divided into four provinces: North, West, South, And East. They are organized into 30 districts. Rwanda's population was estimated to be 13,162,804 people in March 2021 (41). Approximately 17.6% of the Rwandan population live in cities and towns (2,281,330 people in 2020)(41).

Rwanda's elevation ranges from 1,500 to 2,000 meters. Rwanda has a sub-equatorial climate with annual temperatures averaging around 18.5°C and 1,250 mm of rainfall divided into wet and dry seasons (42).

The Rwanda's population is approximately 12.7 million including youth and children (0-24 years) accounting for 60.1% (43).

2.2. Study design

It is a cross sectional retrospective study that uses RDHS 2014/2015 and 2019/2020 data to assess and compare the prevalence of stunting and the factors that influence it.

2.3. Specific objectives' achievement

1. 1. To compare the prevalence of stunting in RDHS 2014/2015 and RDHS 2019/2020 data, graphs, percentages, and frequencies for stunting status were calculated using Stata to allow comparison between these considered RDHSs.
2. To compare the factors contributing to low height for age in children in RDHS 2014/2015 and RDHS 2019/2020 data, chi-square test and multivariable logistic regression were used to identify and compare variables that are significantly associated with stunting status in both RDHSs.

2.4. Study variables

The outcome of the study is stunting among children of 0-59 months from each of considered RDHS. This variable was dichotomized into "Stunted" children as it met the mentioned criteria, otherwise the children was "Not stunted".

The independent variables for this study are children's characteristics like age (months), child's sex, weight at birth, and household characteristics like place of residence, religion, family size, drinking water access, sanitation, wealth index, and mother's variables like age, marital status, education, and occupation, as well as partner's characteristics like age, education, and occupation.

2.5. Analysis plan

Stata version 13 was used for descriptive and regression analyses. The magnitude of stunting across the two surveys was determined using descriptive analyses using frequencies and percentages for the first objective. Graphs and tables were used to compare stunting from two surveys.

The bivariate analysis used chi-square test to determine the pairwise relationship of stunting and each of the potential study predictors for the second objective. The significant variables from the bivariate analysis were imported into the multivariable analysis, which used multiple logistic regression to determine variables related to stunting. The two RDHs were compared using proportions and logistic regression for factors associated with stunting in both RDHS. All required tests were carried out at a five percent significance level. Stata version 13 was used for all data analysis tasks.

2.6. Study population

The study population is made up of children under the age of five, whose anthropometric measures were collected during the RDHS 2014/2015 and 2019/2020.

2.7. Sampling technique and Sample size

According to DHS reports from 2015 and 2020. Each of the two RDHS employed a two-stage sampling to provide national estimates(44). The first stage was to choose sampling homogenous groups from the enumeration area for the 2012 population and housing census. A total of 500 groups were recruited, with 112 located in cities and 388 in rural communities. The second stage involved the selection of the households under consideration. At least 5000 households were

chosen for each survey, and over 3000 children under the age of five were chosen for each of the two surveys (44).

2.8. Data collection

According to the 2019-2020 DHS report, under five children survey was completed by mother of reproductive age between 15-49 years old(11). Additional variables were extracted from women, men and household data sets and added to child data set to provide a complete data set for analyses. These variables include safe water drinking, family size and toilet availability. This facilitated us to depart from the child data sets generated by RDHSs to have the two complete datasets available and analyzed to achieve the study objectives.

2.9. Data management

Since the study used the secondary data from the RDHS 2014/2015 and 2019-2020, data were downloaded and accessed from DHS program. Afterwards, the data were stored on the PC. These data were cleaned and adjusted to the study objectives to facilitate the analysis that targets the achievement of the objectives. Data cleaning was performed using Stata version 13. For the security of data, a strong password for the storing PC were used to limit access on the study dataset.

2.10. Ethics considerations

The permission to carry out this study was given by the University of Rwanda (UR), College of Medicine and Health Science (CMHS) through its IRB that gave us the Ethical Clearance Letter to conduct this this study.

The accessibility to the RDHS dataset came from DHS main program by replying to the request submitted to its website.

In order to maximize the protection of human data, there were protected using a strong password to the computer that was used for data storage and analysis. In addition, as this study did not involve primary data collection, there were no informed consent.

CHAPTER III: RESULTS

3.1 Characteristics of the study subjects

Under 5 Children who were recorded in RDHS 2014/2015 were mostly aged between 6 and 23 months; 33.15% (1081 children). The majority of them were also having a normal weight; 94.63% (3086 children), with a birth order varying from 1 to 3; 69.46% (2265 children). Their mothers were mostly aged 25-34 years; 56.82% (1853 mothers) and their partners were aged between 18 to 35 years 61.46% (1663 men). The most of mothers were living together with their partners; 83.16% (2712 women) with primary education level; 72.4% (2361 women), the same for their partners; 70.15% (2085 men). The predominant wealth index category for their households (HH) was the poorest; 23.52 % (767 HHs) with mothers who were working in agriculture; 71.68% (2336 women), the same for their partners; 59.41% (1765 men). Their religion was mostly Protestantism; 49.28% (3965HHs) residing in rural settings; 77.46% (2526 HHs). The number of HH members was generally varying between 1 to 5 members; 61.27% (1998 HHs) with 1 to 2 members aged under 5 years 88.96% (2901 HHs). The most of HHs were using an unimproved water source; 62.88% (2050 HHs) with pit latrines; 89.05% (2905 HHs) but the disposal of children stool was improved for the majority of them; 84.8% (2757 HHs).

For RDHS 2019/2020, the children under 5 years were male; 50.6% (1902 children) and mostly aged between 6 and 23 months; 31.34 % (1178 children). The most of them were also having a normal weight; 94.23% (3542 children), with a birth order varying between 1 to 3; 65.5% (2462 children). Their mothers were in majority aged 25-34 years; 48.95% (1840 mothers) and their partners were mostly aged between 36 to 53 years; 48.25% (1517 mothers). The most of mothers were living together with their partners; 83.64% (3144 women) with primary education level; 65.26% (2453 women), the same for their partners; 67.88% (2134 men). The predominant wealth index category for their households (HH) was the poorest; 24.13 % (907 HHs) with mothers who were working in agriculture; 41.13% (1546 women) but their partners were manual workers 39.59% (2648 men). Their religion was mostly Protestantism; 48.8% (1591 HHs) residing in rural settings;79.36% (2983 HHs). The number of HH members was generally varying between 1 to 5 members; 40.92 % (1538 HHs) with 1 to 2 members aged under 5 years; 89.6% (3368 HHs). The

most of HHs were using an unimproved water source (56.98%; 2142 HHs) with pit latrines; 87.66% (3295 HHs) contrary the disposal of children stool was improved for the majority of them; 81.92% (2757 HHs).

Table 1: Characteristics of study participants

Variable	RDHS 2014-2015		RDHS 2019-2020	
	Frequency	**Percent**	**Frequency**	**Percent**
Sex of the child				
Male	1,667	51.1	1,902	50.6
Female	1,594	48.9	1,857	49.4
Age (month)				
0-5	309	9.5	374	9.8
6-59	2,952	90.5	3,435	90.2
Weight				
Normal	3,086	94.6	3,542	94.2
Low	175	5.4	217	5.8
Birth order				
1-3	2,265	69.5	2,462	65.5
4-8	939	28.8	1,240	33.0
Sep-13	57	1.8	57	1.5
Mother's age(years)				
15-24	619	19.0	556	14.8
25-34	1,853	56.8	1,840	49.0
35-49	789	24.2	1,363	36.3
Partner's age(year)				
18-35	1,663	61.5	1,511	48.1
36-53	955	35.3	1,517	48.3
54-85	88	3.3	116	3.7
Marital partnership				
Live together	2,712	83.2	3,144	83.6
Do not live together	549	16.8	615	16.4
Women education				
Education	418	12.8	451	12.0
Primary	2,361	72.4	2,453	65.3
Secondary	395	12.1	685	18.2

Higher	87	2.7	170	4.5
Partner's education				
Education	472	15.9	424	13.5
Primary	2,085	70.2	2,134	67.9
Secondary	297	10.0	393	12.5
Higher	111	3.7	176	5.6
Don't know	7	0.2	17	0.5
Wealth index				
Poorest	767	23.5	907	24.1
Poorer	670	20.6	776	20.6
Middle	603	18.5	706	18.8
Richer	567	17.4	692	18.4
Richest	654	20.1	678	18.0
Mother's Occupation				
No occupation	231	7.1	669	17.8
Agriculture	2,336	71.7	1,546	41.1
Services	533	16.4	523	13.9
Manual	128	3.9	988	26.3
domestic occupation	31	1.0	33	0.9
Partner's Occupation				
No occupation	22	0.7	437	6.5
Agriculture	1,765	59.4	2,312	34.6
Services	517	17.4	1,254	18.8
Manual	634	21.3	2,648	39.6
domestic occupation	33	1.1	37	0.6
Religion				
No religion	80	1.0	14	0.4
Catholic	2,758	34.3	1,165	35.7
Protestant	3,965	49.3	1,591	48.8
Adventist	1,025	12.7	397	12.2
Muslim	155	1.9	74	2.3
Others	63	0.8	19	0.6
Residence				
Urban	735	22.5	776	20.6
Rural	2,526	77.5	2,983	79.4
Number of HH members				

1-5	1,998	61.3	2,174	57.8
6-10	1,232	37.8	1,538	40.9
11 and above	31	1.0	47	25.0
Number of children under 5 in HH				
1-2	2,901	89.0	3,368	89.6
3-4	351	10.8	374	10.0
5-7	9	0.3	17	0.5
Improved source of water				
Improved	1,210	37.1	1,617	43.0
Unimproved	2,050	62.9	2,142	57.0
Toilet facility				
Modern toilet	224	6.9	357	9.5
Pit latrine	2,905	89.1	3,295	87.7
No toilet	132	4.1	107	2.9
Disposal of children stool				
Improved	2,757	84.8	1,785	81.9
Not improved	494	15.2	394	18.1

3.2 Prevalence of stunting

The Figure 1 below indicates that 37.9% of children who recoded in RDHS 2014/2015 were stunted. However, 62.2% were not having stunting.

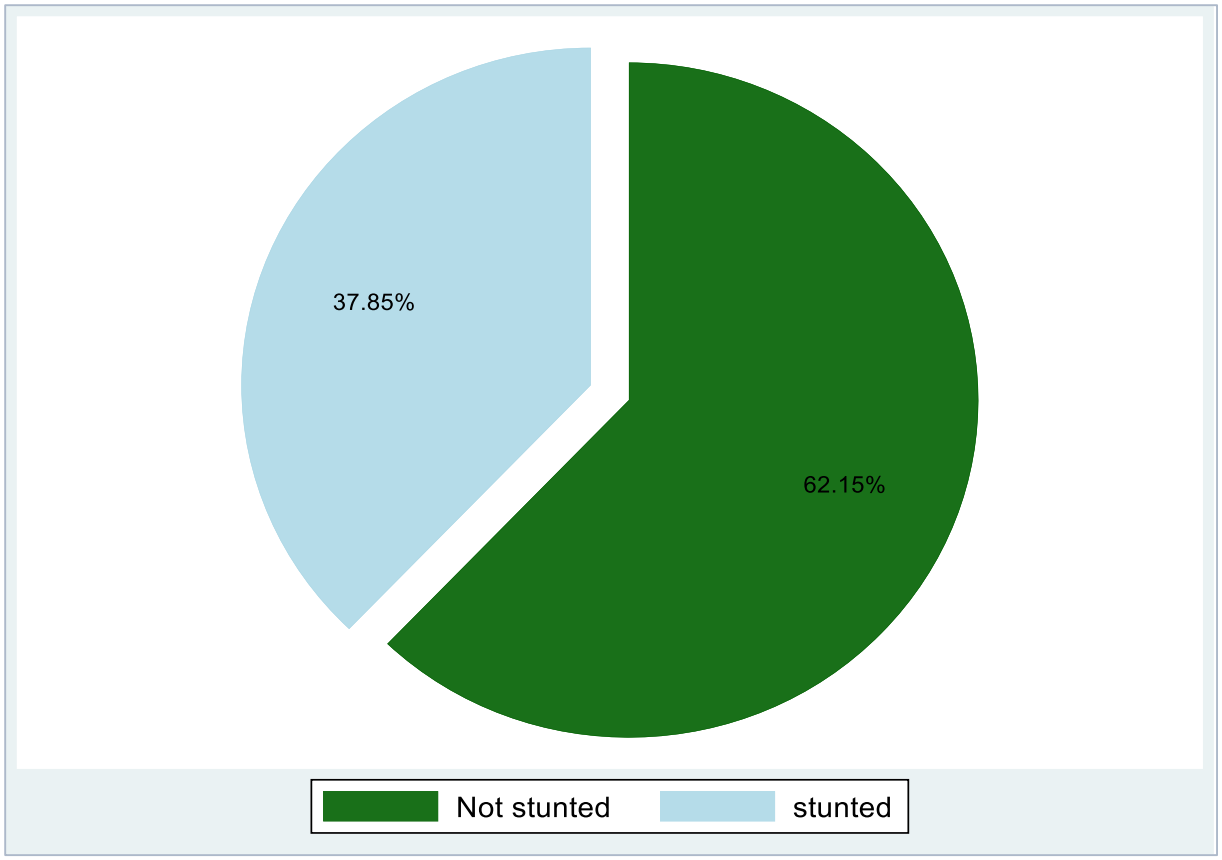

Figure 2: Stunting among children under 5 years for RDHS 2014/2015

For RDHS 2019/2020, the Figure 2 below shows that 33.45% of children who recoded in that RDHS were stunted and 66.6% were not stunted.

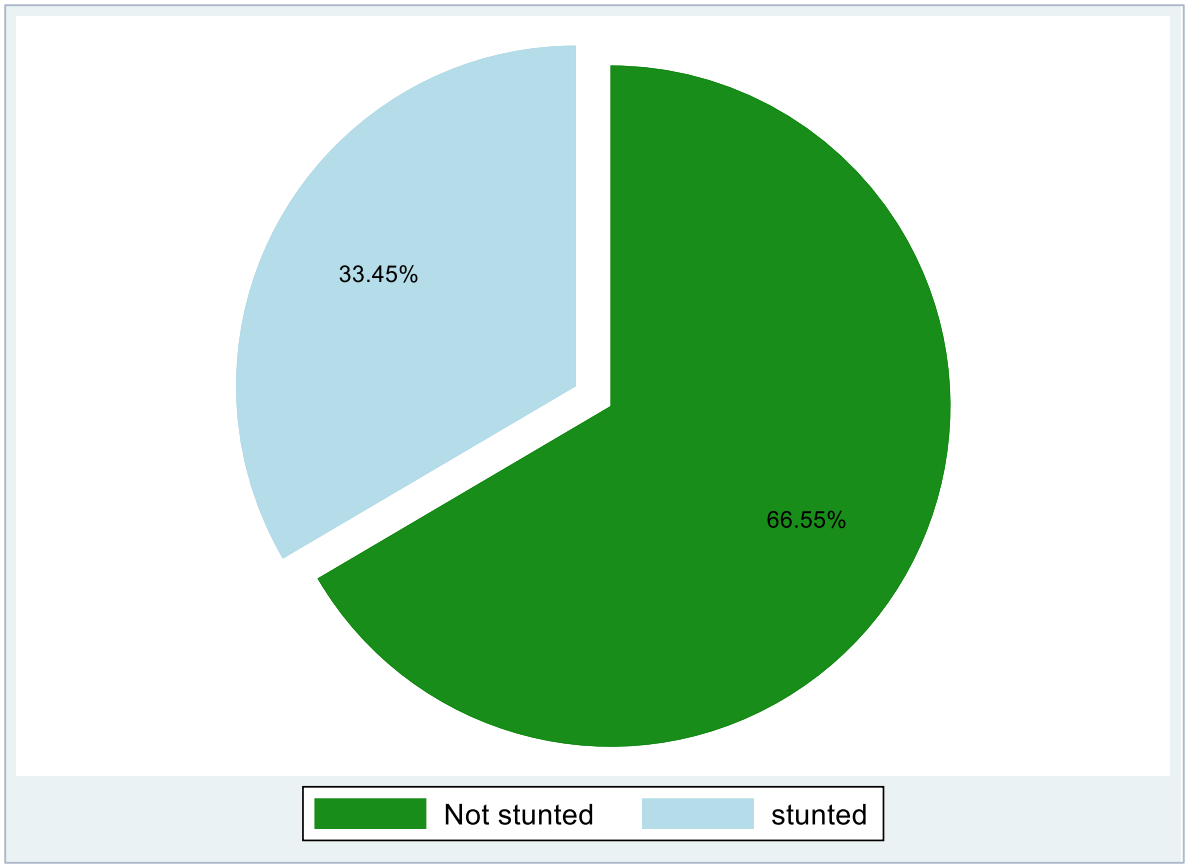

Figure 3: Stunting in children under five years for RDHS 2019/2020

The Figure 4 below for stunting and education categories of the mothers indicates that the primary education level has the highest number of children who were stunted (904 children) and those who were not stunted (1457 children)

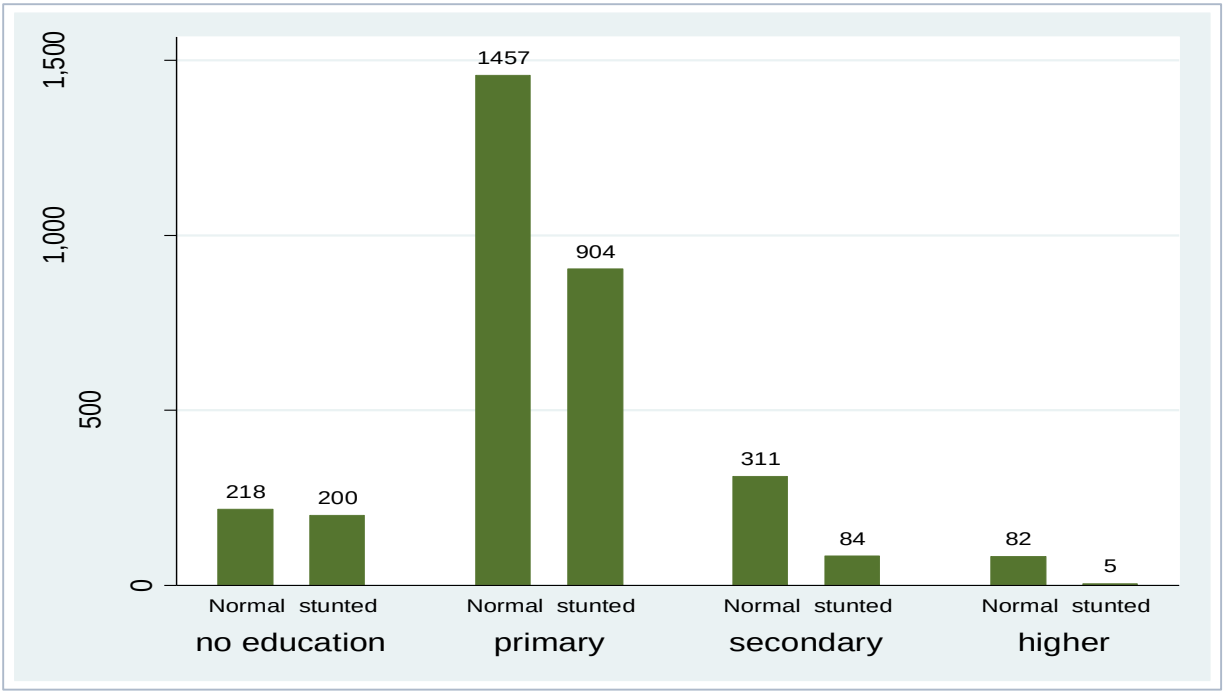

Figure 4: Stunting for children below five years and education of their mothers for RDHS 2014/2015

The Figure 5 below for stunting across the education categories of the mothers indicate that the primary education level predominates for both categories (857 children were stunted and 1575 were not stunted).

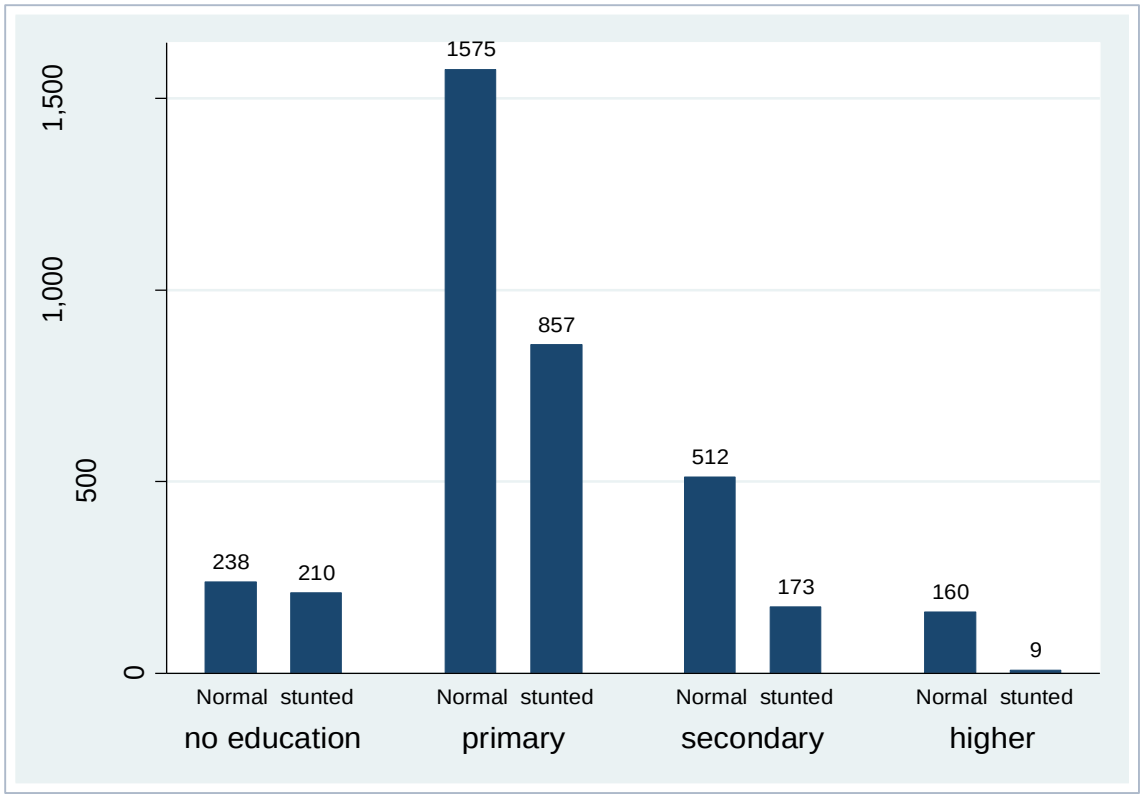

Figure 5: Stunting among kids under the age of 5 years and education of their mothers for RDHS 2019/2020

3.2 Predictors of stunting for Rwandan children aged under five years

3.2.1 Bivariate analysis

The relationship between stunting and each covariate was analyzed using chi-square test of association; the results are shown in Table 2. The sex of child (p-value<0.001), age of the child (p-value<0.001), birth weight (p-value<0.001), birth order (p-value=0.005 for RDHS 2014/2015 and p-value<0.001 for RDHS 2019/2020), age of partner(p-value<0.001), marital partnership (p-value=0.011 for RDHS 2014/2015 and p-value<0.001 for RDHS 2019/2020), women and partner's education(p-value<0.001), wealth index(p-value<0.001), mother and the occupation of the partner (p-value<0.001), religion (p-value<0.001 and p-value=0.002), residence(p-value<0.001), water source(p-value<0.001) and toilet facility (p-value<0.001) were consistently associated with stunting (p-value<0.001).

Table 2: Pairwise relationship analysis between stunting and other independent variable

Variable	RDHS 2014/2015		P-value	RDHS 2019/2020		P-value
	Stunted	Not stunted		Stunted	Not stunted	
Sex of the child			P<0.001			P<0.001
Male	980	687		1,188	701	
Female	1,088	506		1,297	548	
Age (months)						P<0.001
0-5	275	34	P<0.001	301	63	
6-59	1,780	1,172		2,184	1,186	
Birth Weight			P<0.001			P<0.001
Normal	1,983	1,103		2,394	1,126	
low	85	90		91	123	
Birth order			0.005			P<0.001
1-3	1,475	790		1,694	754	
4-8	563	376		755	474	
9-13	30	27		36	21	
Mother's age(years)			0.105			0.016
15-24	415	204		390	163	
25-34	1,164	689		1,233	601	
35-49	489	300		862	485	
Partner's age category (years)			0.001			P<0.001
18-35	1,084	579		1,002	495	
36-53	621	334		1,037	470	
54-85	40	48		72	43	
Marital partnership			0.011			0.001
Live together	1,746	966		2,111	1,008	
Do not live together	322	227		374	241	
Women education			P<0.001			P<0.001
Education	218	200		238	210	
Primary	1,457	904		1,575	857	
Secondary	311	84		512	173	
Higher	82	5		160	9	
Partner's education			P<0.001			P<0.001
Education	257	215		243	175	
Primary	1,304	781		1,399	719	
Secondary	222	75		297	93	
Higher	102	9		161	15	
Don't know	6	1		11	6	
Wealth index			P<0.001			P<0.001
Poorest	397	370		461	428	
Poorer	367	303		459	315	
Middle	377	226		471	234	
Richer	404	163		490	199	
Richest	523	131		604	73	
Mother's Occupation			P<0.001			P<0.001
No occupation	158	73		477	190	
Agriculture	1,408	928		1,010	528	

Services	401	132		415	105	
Manual	82	46		561	418	
Domestic occupation	18	13		22	8	
Partner's Occupation			P<0.001			P<0.001
No occupation	10	12		126	68	
Agriculture	1,054	711		745	382	
Services	398	119		444	135	
Manual	404	230		781	421	
Domestic occupation	24	9		15	2	
Religion			P<0.001			0.002
No religion	4	10		23	28	
Catholic	738	427		840	421	
Protestant	994	597		1,223	618	
Adventist	254	143		311	158	
Muslim	61	13		61	19	
Others	17	2		27	5	
Residence			P<0.001			P<0.001
Urban	558	177		614	156	
Rural	1,510	1,016		1,871	1,093	
HH members			0.262			0.199
1-5	1,262	736		1,461	696	
6-10	782	450		993	537	
11 and above	24	7		31	16	
Number of children under 5 in HH			0.452			0.172
1-2	1,831	1,070		2,244	1,105	
3-4	230	121		229	139	
5-7	7	2		12	5	
Improved source of water			P<0.001			P<0.001
Improved	850	360		1,168	443	
Unimproved	1,218	832		1,317	806	
Toilet facility			P<0.001			P<0.001
Modern toilet	160	64		270	85	
Pit latrine	1,844	1,061		2,152	1,127	
No toilet	64	68		63	37	
Disposal of children stool			0.01			0.799
Improved	1,724	1,033		1,205	566	
Not improved	339	155		270	123	

3.2.2 Multivariable analysis

The multiple logistic regression model was used to identify the variables that are significantly associated with stunting of children under five years in Rwanda using RDHS 2014/2015 and RDHS 2019/2020. The results of analysis are shown in Table 3 below.

In 2015, the analysis results show that the sex of the child; female versus male (OR=0.63, P-value<0.001), child age categories: 6-23months (OR=4.39, P-value<0.001), 24-35months (OR=6.30, P-value<0.001), 36-47months (OR=5.65, P-value<0.001), 48-59months (OR=4.24, P-value<0.001) as compared to 1-5 months were linked with stunting. The low weight as compared to the normal weight was also linked to the stunting in children under five years (OR=2.16, P-value<0.001). The women's secondary (OR=2.16, P-value<0.001) and higher (OR=0.26, P-value<0.001) education levels as compared to no formal education were associated with the decrease in stunting for children considered in study. Similarly, the middle (OR=0.65, P-value=0.001), the richer (OR=0.0.46, P-value<0.001) and the richest (OR=0.0.42, P-value<0.001) wealth index category versus the poorest category were also associated with the decrease in stunting among children. Additionally, the residence type; rural (OR=1.37, P-value=0.048) versus urban was associated with the increase in stunting for children in Rwanda (children aged below five years).

For RDHS 2019/2020, the same table indicates that the sex of the child; female versus male (OR=0.60, P-value<0.001) was associated with the decrease in stunting, child age categories: 6-23months (OR=2.54, P-value<0.001), 24-35months (OR=7.56, P-value<0.001), 36-47months (OR=3.92, P-value<0.001), 48-59months (OR=2.97, P-value<0.001) as compared to 1-5 months were associated the increase of stunting in children under five years. The low weight as compared to the normal weight was connected with low height for age of children under five (OR=3.49, P-value<0.001). Similarly, the poorer (OR=0.69, P-value=0.017), the middle (OR=0.57, P-value=0.001), richer (OR=0.0.48, P-value<0.001) and the richest (OR=0.15, P-value<0.001) wealth index categories versus the poorest category were also related to the decrease in stunting for children below five years in Rwanda.

Table 3: Predictors of Stunting in Rwandan children

Variable	RDHS 2014/2015				RDHS 2019/2020			
	OR	P-value	95% CI		OR	P-value	95% CI	
Sex of the child								
Male	1.0				1			
Female	0.6	P<0.001	0.5	0.8	0.6	P<0.001	0.5	0.8
Age								
0-5months	1.0				1			
6-23months	4.8	P<0.001	3.2	7.4	3.1	P<0.001	2.2	4.4
Weight								
Normal	1.0				1			
Low	2.1	P<0.001	1.4	3.1	3.5	P<0.001	2.2	5.5
Birth order								
1-3 order	1.0				1			
4-8 order	1.2	0.164	0.9	1.5	1.2	0.139	0.9	1.7
9-13 order	1.8	0.09	0.9	3.4	1.2	0.598	0.6	2.6
Mother's age								
15-24 years	1.0				1			
25-34 years	1.2	0.136	0.9	1.6	1.3	0.105	0.9	1.9
35-49 years	1.2	0.374	0.8	1.7	1.4	0.118	0.9	2.2
Partner's age								
18-35 year	1.0				1			
36-53 year	1.0	0.646	0.8	1.2	1.0	0.904	0.7	1.3
54-85 year	1.6	0.059	1.0	2.6	0.7	0.265	0.3	1.4
Women's education								
No-education	1.0				1			
Primary	0.9	0.297	0.7	1.1	0.8	0.273	0.6	1.2
Secondary	0.6	0.013	0.4	0.9	0.8	0.398	0.5	1.3
Higher	0.3	0.011	0.1	0.7	0.4	0.129	0.1	1.3
Husband/Partner's education								
education	1.0				1			
primary	1.0	0.662	0.8	1.2	0.9	0.623	0.7	1.3
secondary	0.9	0.443	0.6	1.3	0.8	0.419	0.5	1.3
higher	0.5	0.162	0.2	1.3	0.5	0.105	0.2	1.2
don't know					0.9	0.901	0.3	3.1
Wealth index								
poorest	1.0				1			
poorer	0.9	0.231	0.7	1.1	0.7	0.015	0.5	0.9
middle	0.7	0.001	0.5	0.8	0.6	0.001	0.4	0.8

richer	0.5	P<0.001	0.4	0.6	0.5	P<0.001	0.3	0.7
richest	0.4	P<0.001	0.3	0.7	0.2	P<0.001	0.1	0.3
Mother's Occupation								
No occupation	1.0				1			
Agriculture	0.8	0.198	0.5	1.1	0.8	0.166	0.6	1.1
Services	1.0	0.84	0.7	1.6	1.0	0.972	0.6	1.6
Manual	1.1	0.722	0.6	2.0	1.1	0.677	0.8	1.5
domestic occupation	1.8	0.266	0.6	5.1	1.5	0.613	0.3	7.2
Partner's Occupation								
No occupation	1.0							
Agriculture	0.6	0.251	0.2	1.5	1.1	0.861	0.6	1.8
Services	0.5	0.115	0.2	1.2	1.5	0.181	0.8	2.5
Manual	0.7	0.426	0.3	1.8	1.1	0.811	0.7	1.7
domestic occupation	0.4	0.178	0.1	1.5	0.3	0.224	0.0	2.3
Religion								
No religion	1.0				1			
Catholic	0.3	0.1	0.1	1.3	0.8	0.65	0.3	2.3
Protestant	0.3	0.12	0.1	1.4	0.8	0.758	0.3	2.5
Adventist	0.2	0.056	0.1	1.0	0.8	0.696	0.3	2.5
Muslim	0.1	0.01	0.0	0.6	0.9	0.838	0.2	3.5
Others	0.1	0.057	0.0	1.1	0.4	0.297	0.1	2.2
Residence								
urban	1.0				1			
rural	1.4	0.034	1.0	1.9	1.2	0.376	0.8	1.7
Improved source of water								
Improved	1.0				1			
Unimproved	1.0	0.885	0.8	1.2	0.9	0.349	0.7	1.1
Toilet facility								
Modern toilet	1.0				1			
Pit latrine	1.0	0.798	0.7	1.4	1.0	0.881	0.6	1.5
No toilet	1.6	0.117	0.9	2.9	0.7	0.438	0.3	1.7
Disposal of children stool								
Improved	1.0				1			
Not improved	0.9	0.662	0.7	1.2	1.3	0.136	0.9	1.7
Constant	1.3	0.769	0.2	8.6	0.4	0.178	0.1	1.6

Discussion

The overall objective of this study was to explore RDHS data, determine and compare the level of stunting in children of 5 years or below and the factors contributing to stunting in RDHS 2014/2015 and 2019/2020.

The descriptive data analysis of stunting showed that the low height for age prevalence in children below five years was 37.9 % in 2014/2015 and 33.4% in 2019/2020. This indicates a slight decrease between the two RDHSs. This was lower as compared the expectations due to the programs put in place by the government of Rwanda to fight malnutrition in children under five years. These initiatives include giving out fortified and synthetized flour to mother with young children, working with community health workers to involve parents of undernourished kids, and launching a variety of campaigns to encourage mothers to nurse their kids from an early age. Other initiatives include bolstering the One-Cow-Per-Poor-Family intervention, which enables low-income families to provide milk to their kids, and educating community based health workers to instruct parents on cooking a healthy food for their kids while still adhering to appropriate food cleanliness. (45). However, this level of stunting is among the lowest in SSA that has an average of 41% (46). Though it is among the highest in East African community; the second after that of Burundi (54%) but before that of Kenya (26%), Tanzania (32%) and Uganda (33%) (47–49).

A multivariable analysis with multiple logistic regression models was performed to find predictors of stunting among children in Rwanda in 2014/15 and 2019/2020. It was revealed that in 2015, the sex of the child; (female versus male), the birth weight (low versus normal weight), and the wealth index (all categories versus the poorest) for both RDHS were associated with the decline of stunting in Rwandan children . Similar results were reached by a study conducted in Tanzania that found that being stunted was more probable among female than male children (50). This may be explained by differences in gender related to natural stamina to stand against health threats (51). Another study conducted in Uganda found that the wealth index was an influencer factor of stunting among children in that country. The wealth index is an indicator of wellbeing and an important tool for an improved nutritional level and diversity in a household that may be protective against stunting in children of the same household (52). Additionally, this study revealed the age

of child to be also related to stunting among children from the Northern Uganda (53). Another study that was carried out in Tanzania found that older child's age was statistically related to the stunting in children of 0-23 months that was significantly greater in male than female children (54). This may explain the effect that age plays in causing or facilitating stunting in children. For this, it was found that Stunting increases with age, having 14% children stunted at 6 months as compared to 46% affected at the age of 18 to 23 months(55).

The low weight as compared to the normal weight was influencing stunting in children for both surveys. Similar results were found by systematic review on stunting in Sub Saharan Africa between 2000 and 2020 found that stunting was higher in children with lower weight at birth (46). Thus, the low birth weight has been found to be a determinant of stunting as the children who were born with low weight remain vulnerable to several disease and other health adversities such stunting. A study conducted in Pakistan revealed that Children born with low birth weight are highly vulnerable to develop diseases and death and/or remained stunted or wasted (56).

Not only was low birth weight associated with a higher risk of stunting, but a 2017 study in Ghana also found that male children were more likely to be stunted than their female counterparts. When compared to children aged 6-8 months, older children aged 12-23 months were at an increased risk of stunting. (57).

This study also found that the mother's education level (secondary and higher as compared to the lack of formal education) was found to be linked a declined risk of having stunting in 2014/2015. A study carried out in Ethiopia revealed that the lack of formal education that is a reference category for our study was discovered to be linked with an increase in the risk of stunting (58). Another study conducted in the same country based on Demographic and Health Survey in 2016 showed that stunting in children was negatively connected with a higher level of education (secondary and higher education) for the mother (59). The education for the mother is a key indicator of the stunting among children in several ways. First, formal maternal education directly provides health knowledge to girls of reproductive age. Second, the skills learned from school help them recognize potential illness and encourage them to seek for treatment of the children. Furthermore, they are also able to read and apply medical information regarding the treatment of childhood illnesses. Third, having more school years makes women more open the mothers to modern pediatric medicine. Another research has discovered a stronger relationship between

women's education, socio-economic status, and nutritional status of child such as stunting. This is because educated women are more probable to have stable, well-paying occupations; marry educated with enough income; and reside in convenient neighborhoods, all of which possess an impact on child health against any life threat such as stunting (60–62).

The results of our study also indicated that the residence in rural areas versus living in urban settings was associated with the stunting for children in Rwanda. This was also found by a study conducted in Tanzania; this study aimed examining the difference of under-5 child stunting prevalence between urban and rural showed that stunting was more significant in rural than urban places (63).

A study conducted in Pakistan discovered that 44.4% of under-five children were stunted (this prevalence was higher than that found by this study). Children whose mothers lived in rural areas were more likely to be stunted (the same the results of this study mentioned above)(64). Another study conducted in Jombang District in Indonesia revealed that the risk of stunting decreased with higher education and higher family income (65). Additionally, a study conducted in Bangladesh specified that the stunting prevalence was overall 36.3 percent, with rural areas having a substantially greater prevalence than urban areas (38.1 percent) (31.2 percent). Stunting was far more likely to occur in children having 36 to 47 months from the financially disadvantaged homes. In remote parts, stunted youngsters were mostly male. Another important risk factor for childhood stunting was maternal education. (66). These results are more or less related to ours.

Study limitation

This study analyzed the secondary data from a large survey assessing a big number of indicators, and thus could not avoid the lack of some important variables among the available data such as patho-physiological and genetic involvement and implications.

Additionally, as the data were corrected for a different purpose, therefore the analysis to achieve the objectives of this study may be subjected to some bias and consequently, the results were interpreted and generalized with enough caution.

Conclusion

The findings of the study indicated that the prevalence of stunting in children under five years was 37.9 % in 2014/2015 and 33.4% in 2019/2020. This indicates a decrease between the two RDHSs.

A multivariable analysis found that the sex of child; (female versus male), the birth weight (low versus normal weight), and the wealth index (all categories versus the poorest) for both RDHS were associated with a decreased stunting of Rwandan children.

This study also found that the level of education for the mother (secondary and higher as compared to the lack of formal education) was identified to be connected with the decrease in the risk of having stunting in 2014/2015.

The results of our study also indicated that the residence in rural areas versus living in urban settings was associated with the increase level of stunting among for children in Rwanda.

As recommendations; the mothers and their partners should be sensitized on improving nutrition of children to reduce malnutrition (stunting) level that is still high in Rwanda.

According to the results of this study the male children should receive much attention such as postnatal care seeking to prevent stunting among them.

The wealth index was revealed to be a significant factor influencing stunting among children in Rwanda thus all interventions aiming at improving household income should be emphasized; this may include creation of new jobs and opportunity for the mothers and their partners with special attention to rural dwellers as it was also found to be associated with stunting much higher compared urban settings.

Policy implications

As mentioned in the problem statement the stunting in children has been and remains public health challenge that have highly attracted GoR and its partner's attention until today. Several research works have been carried out on stunting; however, none have been carried out to compare the current situation of stunting from the current RDHS with the previous one. Therefore, this study intended to provide a starting point for researcher and policy makers who are interested in comparing stunting prevalence and associated factors over time.

More precisely, this work is informing the decision makers in the field of nutrition and child development to develop programs to address a well- explored threat through eliminating negative factors that aggravate the problem and strengthen factors recognized to be in association with the stunting for children in Rwanda.

Academically, this work will contribute to other studies aiming at exploring the level and determinant of stunting in Rwandan children up to five years.

References

1. Hank P. Merriam Webster's advanced learners' dictionary. Retrived; 2016.
2. Organization WH. Nutrition Landscape Information System (NLIS) country profile indicators: interpretation guide. 2019;
3. DHS Program. The DHS Program - Demographic and Health Survey (DHS) [Internet]. [cited 2021 Aug 27]. Available from: https://dhsprogram.com/methodology/survey-Types/DHS.cfm
4. UNICEF. Malnutrition in Children - UNICEF DATA [Internet]. [cited 2021 Aug 27]. Available from: https://data.unicef.org/topic/nutrition/malnutrition/
5. United Nations Children's Fund (UNICEF), World Health Organization, World Bank Group. Levels and trends in child malnutrition: key findings of the 2019 Edition of the Joint Child Malnutrition Estimates. Geneva: WHO; 2019. Available from: https://www.who.i.
6. Food and Agriculture Organization of the United Nations IFfAD, Unicef, World Food Program, World Health Organization. THE STATE OF FOOD SECURITY AND NUTRITION IN THE WORLD. BUILDING RESILIENCE FOR PEACE AND FOOD SECURITY, Rome, FAO. 2017.
7. UNICEF / WHO / World Bank Group Joint Child Malnutrition Estimates.Levels and trends in child malnutrition: Key findings [Internet]. 2019. Available from: https://www.who.int/nutgrowthdb/jme-2019-key-findings.pdf
8. Levels and trends in child malnutrion.UNICEF / WHO / World Bank Group Joint Child Malnutrition Estimates Key findings of the 2020 edition. Accessed on January 29, 2021.
9. De Onis M, Branca F. Childhood stunting: a global perspective. Matern Child Nutr. 2016;12(S1):12–26.
10. Emerson E, Savage A, Llewellyn G. Prevalence of underweight, wasting and stunting among young children with a significant cognitive delay in 47 low-income and middle-income countries. J Intellect Disabil Res. 2020;64(2):93–102.
11. NISR. National Institute of Statistics of Rwanda (NISR) .The DHS Program ICF Rockville,

Maryland, USA .Rwanda Demographic and Health Survey 2019-20 Key Indicators Report. Kigali; 2020.

12. Danaei G, Andrews KG, Sudfeld CR, et al. Risk factors for childhood stunting in 137 developing countries: a comparative risk assessment analysis at global, regional, and country levels. PLoS Med. 2016;13:1–18. doi:10.1371/journal.pmed.1002164.

13. Francisco J, Ferrer L, Serra-Majem L. Factors associated with stunting among children. Nutrients. 2017;9:1–16.

14. Age M, District G, Zone EW. Prevalence of stunting and associated factors of children among 6-59 prevalence of stunting and associated factors of children among 6-59 months age in Guto Gida District, East Wollega Zone. Food Sci Qual Manag. 2016;29:1–17.

15. Abdulazeez Imam, Fatimah Hassan-Hanga, Azeezat Sallahdeen, Zubaida L Farouk, A cross-sectional study of prevalence and risk factors for stunting among under-fives attending acute malnutrition treatment programmes in north-western Nigeria.

16. Isanaka S, Hitchings MDT, Berthé F et al. . Linear growth faltering and the role of weight attainment: prospective analysis of young children recovering from severe wasting in Niger. Matern Child Nutr. 2019;15(4):e12817.

17. National Bureau of Statistics. National nutrition and health survey (NNHS) 2018. https://www.unicef.org/nigeria/media/2181/file/Nigeria-NNHS-2018.pdf. Accessed 26 january 2021.

18. Amare Lisanu Mazengia, Gashaw Andargie Biks, “Predictors of Stunting among School-Age Children in Northwestern Ethiopia”, Journal of Nutrition and Metabolism, vol. 2018, Article ID 7521751, 7 pages, 2018. https://doi.org/10.1155/2018/7521751.

19. Odei Obeng-Amoako GA, Wamani H, Conkle J, Aryeetey R, Nangendo J, Mupere E, et al. (2020) Concurrently wasted and stunted 6-59 months children admitted to the outpatient therapeutic feeding programme in Karamoja, Uganda: Prevalence, characteristics, treat.

20. Sheela S. Sinharoy Wolf-Peter Schmidt Kris Cox Zachary Clemence Leodomir Mfura Ronald Wendt Sophie Boisson Erin Crossett Karen A. Grépin William Jack Jeanine Condo James Habyarimana Thomas Clasen et al. Child diarrhoea and nutritional status in rural

Rwanda: a cross-sectional study to explore contributing environmental and demographic factors. Trop Med Int Health. 2016;

21. Dusingizimana T. An investigation of factors associated with child stunting in northwest Rwanda: the role of care practices related to child feeding and health: a thesis presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Nutritio. Massey University; 2021.

22. USAID. Rwanda : Nutrition Profile. American [Internet]. 2019;(June):7–10. Available from: https://www.usaid.gov/sites/default/files/documents/1864/Rwanda-Nutrition-Profile-Mar2018-508.pdf

23. National Institute of Statistics of Rwanda (NISR) [Rwanda], Ministry of Health (MOH) [Rwanda], ICF Internationa. Rwanda Demographic and Health Survey 2019-2020, Key indicators. Kigali; 2020.

24. World Bank. Tackling Stunting: Rwanda's Unfinished Business [Internet]. [cited 2021 Aug 27]. Available from: https://www.worldbank.org/en/country/rwanda/publication/tackling-stunting-rwandas-unfinished-business

25. WHO. Nutrition [Internet]. 2022 [cited 2022 Jun 3]. Available from: https://www.who.int/data/gho/data/themes/topics/sdg-target-2_2-malnutrition

26. Hemalatha R, Radhakrishna K V, Kumar BN. Undernutrition in children & critical windows of opportunity in Indian context. Indian J Med Res [Internet]. 2018 Nov;148(5):612–20. Available from: https://pubmed.ncbi.nlm.nih.gov/30666986

27. Lartey A. What would it take to prevent stunted growth in children in sub-Saharan Africa? Proc Nutr Soc [Internet]. 2015/04/24. 2015;74(4):449–53. Available from: https://www.cambridge.org/core/article/what-would-it-take-to-prevent-stunted-growth-in-children-in-subsaharan-africa/2DC8CBDB9D318659CCE35E5A9D57B34E

28. UNICEF. Nutrition [Internet]. 2021 [cited 2022 Apr 2]. Available from: https://www.unicef.org/rwanda/nutrition

29. Netmeds.com. Stunted Growth: Causes, Symptoms And Prevention [Internet]. 2022 [cited 2022 Apr 2]. Available from: https://www.netmeds.com/health-library/post/stunted-

growth-causes-symptoms-and-prevention

30. Black RE, Heidkamp R. Causes of Stunting and Preventive Dietary Interventions in Pregnancy and Early Childhood. In: Nestlé Nutrition Institute Workshop Series [Internet]. 2018. p. 105–13. Available from: https://www.karger.com/DOI/10.1159/000486496

31. Shrimpton R, Kachondham Y. Analysing the causes of child stunting in DPRK. New York UNICEF. 2003;

32. Vilcins D, Sly PD, Jagals P. Environmental risk factors associated with child stunting: a systematic review of the literature. Ann Glob Heal. 2018;84(4):551.

33. Budge S, Parker AH, Hutchings PT, Garbutt C. Environmental enteric dysfunction and child stunting. Nutr Rev [Internet]. 2019 Apr 1;77(4):240–53. Available from: https://doi.org/10.1093/nutrit/nuy068

34. Raihan MJ, Briskin E, Mahfuz M, Islam MM, Mondal D, Hossain MI, et al. Examining the relationship between blood lead level and stunting, wasting and underweight-A cross-sectional study of children under 2 years-of-age in a Bangladeshi slum. PLoS One. 2018;13(5):e0197856.

35. Deshpande A, Ramachandran R. Which Indian children are short and why? Social identity, Childhood Malnutrition and Cognitive Outcomes. 2020.

36. Sadida ZJ, Indriyanti R, Setiawan AS. Does growth stunting correlate with oral health in children?: a systematic review. Eur J Dent. 2022;16(01):32–40.

37. Kapoor A, Channa NA, Soomro AM, Tunio SA, Khand TU, Memon N. Malnutrition and clinical manifestations in school going children at district Tharparkar, Sindh, Pakistan. Rawal Med J. 2018;43:115–9.

38. Binagwaho A, Rukundo A, Powers S, Donahoe KB, Agbonyitor M, Ngabo F, et al. Trends in burden and risk factors associated with childhood stunting in Rwanda from 2000 to 2015: policy and program implications. BMC Public Health [Internet]. 2020;20(1):83. Available from: https://doi.org/10.1186/s12889-020-8164-4

39. Uwiringiyimana V, Ocké MC, Amer S, Veldkamp A. Predictors of stunting with particular

focus on complementary feeding practices: A cross-sectional study in the northern province of Rwanda. Nutrition [Internet]. 2019;60:11–8. Available from: https://www.sciencedirect.com/science/article/pii/S0899900718304611

40. MOH and NISR. Rwanda Demographic and Health Survey 2014-15. Rockville, Maryland, USA NISR, MOH, ICF Int. 2015;

41. Worldometer. Rwanda population [Internet]. Department of Economic and Social Affairs, Population Division. 2021. p. 11. Available from: https://www.worldometers.info/world-population/rwanda-population/#:~:text=Rwanda 2020 population is estimated,of the total world population.

42. Oppong JR. Modern World Countries: Rwanda. South Dakota: Chelsea House Publishers; 2008.

43. Central Intelligence Agence (CIA). Introduction :: RWANDA [Internet]. 2020 [cited 2020 Dec 19]. Available from: https://www.cia.gov/library/publications/resources/the-world-factbook/geos/print_rw.html

44. NISR. Rwanda Demographic and Health Survey 2019-2020: Final Report. Vol. 53, Demographic and Health Surveys. Kigali, Rwanda; 2020. 1689–1699 p.

45. Reliefweb.int. Rwanda's programmes for ending child malnutrition - Rwanda | ReliefWeb [Internet]. [cited 2022 Jul 2]. Available from: https://reliefweb.int/report/rwanda/rwanda-s-programmes-ending-child-malnutrition

46. Quamme SH, Iversen PO. Prevalence of child stunting in Sub-Saharan Africa and its risk factors. Clin Nutr Open Sci [Internet]. 2022;42:49–61. Available from: https://www.sciencedirect.com/science/article/pii/S2667268522000092

47. USAID. Tanzania: Nutrition Profile, (updated June 2021). 2021;(June).

48. USAID. Uganda : Nutrition Profile. 2021;(June).

49. UNICEF-Kenya. Nutrition [Internet]. [cited 2022 Jul 2]. Available from: https://www.unicef.org/kenya/nutrition

50. Sunguya BF, Zhu S, Mpembeni R, Huang J. Trends in prevalence and determinants of

stunting in Tanzania: an analysis of Tanzania demographic health surveys (1991–2016). Nutr J [Internet]. 2019;18(1):85. Available from: https://doi.org/10.1186/s12937-019-0505-8

51. Klein SL, Flanagan KL. Sex differences in immune responses. Nat Rev Immunol [Internet]. 2016;16(10):626–38. Available from: https://doi.org/10.1038/nri.2016.90

52. Hong R, Banta JE, Betancourt JA. Relationship between household wealth inequality and chronic childhood under-nutrition in Bangladesh. Int J Equity Health [Internet]. 2006;5(1):15. Available from: https://doi.org/10.1186/1475-9276-5-15

53. Ren Y, Griswold S, Ocamanono G, Hebie M, Schoenmakers K, Webb P, et al. Factors Associated With Stunting Among Infants and Young Children Aged 7–29 Months in Post-conflict Northern Uganda. Curr Dev Nutr [Internet]. 2021 Jun 1;5(Supplement_2):805. Available from: https://doi.org/10.1093/cdn/nzab046_102

54. Chirande L, Charwe D, Mbwana H, Victor R, Kimboka S, Issaka AI, et al. Determinants of stunting and severe stunting among under-fives in Tanzania: evidence from the 2010 cross-sectional household survey. BMC Pediatr [Internet]. 2015;15(1):165. Available from: https://doi.org/10.1186/s12887-015-0482-9

55. News Medical Life Sciencss. Risk Factors for Stunted Growth [Internet]. 2018 [cited 2022 Sep 7]. Available from: https://www.news-medical.net/health/Risk-Factors-for-Stunted-Growth.aspx

56. Abbas F, Kumar R, Mahmood T, Somrongthong R. Impact of children born with low birth weight on stunting and wasting in Sindh province of Pakistan: a propensity score matching approach. Sci Rep [Internet]. 2021;11(1):19932. Available from: https://doi.org/10.1038/s41598-021-98924-7

57. Ali Z, Saaka M, Adams A-G, Kamwininaang SK, Abizari A-R. The effect of maternal and child factors on stunting, wasting and underweight among preschool children in Northern Ghana. BMC Nutr. 2017;3(1):1–13.

58. Tafesse T, Yoseph A, Mayiso K, Gari T. Factors associated with stunting among children aged 6–59 months in Bensa District, Sidama Region, South Ethiopia: unmatched case-

control study. BMC Pediatr [Internet]. 2021;21(1):551. Available from: https://doi.org/10.1186/s12887-021-03029-9

59. Amaha ND, Woldeamanuel BT. Maternal factors associated with moderate and severe stunting in Ethiopian children: analysis of some environmental factors based on 2016 demographic health survey. Nutr J [Internet]. 2021;20(1):18. Available from: https://doi.org/10.1186/s12937-021-00677-6

60. Cleland JG, Van Ginneken JK. Maternal education and child survival in developing countries: the search for pathways of influence. Soc Sci Med. 1988;27(12):1357–68.

61. Frost MB, Forste R, Haas DW. Maternal education and child nutritional status in Bolivia: finding the links. Soc Sci Med. 2005;60(2):395–407.

62. Desai S, Alva S. Maternal education and child health: is there a strong causal relationship? Demography. 1998;35(1):71–81.

63. Zhu W, Zhu S, Sunguya BF, Huang J. Urban–Rural Disparities in the Magnitude and Determinants of Stunting among Children under Five in Tanzania: Based on Tanzania Demographic and Health Surveys 1991–2016. Int J Environ Res Public Health. 2021;18(10):5184.

64. Khan S, Zaheer S, Safdar NF. Determinants of stunting, underweight and wasting among children < 5 years of age: evidence from 2012-2013 Pakistan demographic and health survey. BMC Public Health [Internet]. 2019;19(1):358. Available from: https://doi.org/10.1186/s12889-019-6688-2

65. Rahmawati VE, Pamungkasari EP, Murti B. Determinants of stunting and child development in Jombang District. J Matern Child Heal. 2018;3(1):68–80.

66. Akram R, Sultana M, Ali N, Sheikh N, Sarker AR. Prevalence and determinants of stunting among preschool children and its urban–rural disparities in Bangladesh. Food Nutr Bull. 2018;39(4):521–35.