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ABSTRACT

Background: Childhood stunting remains a major public health problem in developing countries because of its association with increased morbidity and mortality. In Guinea, the prevalence of childhood stunting has increased from 30.5% to 31.2% between 1999 and 2012. This study aimed to identify factors associated with stunting and severe stunting among children aged less than five years in Guinea.

Methods: The study used a cross-sectional data from the 2012 Guinean Demographic and Health Survey which included 3176 children aged 0-59 months. The 2016 WHO Height-for-age Z-score (HAZ) was used to classify stunting as moderate stunting (HAZ <- 2 standard deviation) and severe stunting (HAZ <-3 standard deviation). Multivariate and multinomial logistic regressions were used to identify risk factors associated with stunting.

Results: The prevalence of child stunting was higher in boys (32.69%) than in girls (29.12%). Age was a significant determinant of stunting with the highest odds among children aged 24-35 months (Adjusted OR=6.82; 95%CI=4.37, 10.63). Children from Mamou (Adjusted OR=2.17 95% CI 1.16, 4.05) and N'zerekore (Adjusted OR=2.05 95% CI 1.15, 3.66) were more likely to be stunted compared to those from the capital city Conakry. The other factors associated with growth faltering were wealth index (poorest, poorer, and middle), short birth interval (less than 24 months, 24 to 47 months), mother's low body mass index (less than 18.5 kg/m^2) and source of drinking water (unimproved).

Conclusion: Our findings suggest that intervention to address childhood stunting in Guinea should focus on poverty alleviation as well as improving women's nutrition, child feeding practices, household sanitation and family planning.

Author’s Statement Page

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Abdoulaye Fatoumata Bangoura

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CHAPTER I Introduction

Nearly 3.5 million children die every year due to inadequate maternal and child nutrition (Onis et al., 2008). Malnutrition, encompassing both under-nutrition (stunting, wasting, underweight) and over-nutrition (overweight, obesity), is a major problem with significant consequences for survival, healthy development, and the economic productivity of individuals and societies (Adelo et al., 2015; Black et Al., 2013). It accounts for over 50% of the annual deaths of children under five years of age who die from preventable causes (Collins et al., 2006). Importantly, child under-nutrition is a major contributor to global burden of disease, leading to millions of children's death in the developing countries and causing massive health expenditures (Black et al., 2003; United Nation 2004). Stunting, the most prevalent form of undernutrition, results from failure to receive adequate nutrition over an extended period. It is identified by measuring a child length (for children less than two years) or height (for children two years or older) and comparing this measurement with an acceptable set of standard values developed by the World Health Organization (WHO). According to this standard, Children are considered stunted when they have height-for-age z-score (HAZ) below two standard deviations (-2SD) from the WHO Child Growth Standards median for the same age and sex. Similarly, children are considered severely stunted if their height-for-age z-core is below three standard deviations (-3SD) from the median of the reference population.

Stunting begins in utero and continues for at least the first two years of postnatal life; the period from conception to a child's second birthday (the first thousand days) has therefore been identified as the most critical window of opportunity for interventions (World Health Organization, 2014). The average length-for-age Z-score among newborns in developing countries is approximately -0.5 and continues to decline after birth to reach a value of -2.0 by 18–24 months of age (Victora et al., 2010). Upon publication of new WHO growth standards in 2006 (World Health Organization, 2006), it became apparent that linear growth faltering in developing countries occurs sooner after birth than had been appreciated using prior National Center for Health Statistics (NCHS) data which were based on the growth of predominantly formula-fed infants.

According to the World Health Organization (WHO), poor linear growth or stunting has short and long-term consequences. Stunting, in the short term, contributes to the increase in morbidity and mortality from infections such as pneumonia and diarrhea. In their prospective study in Sudan for example, Kossmann and colleagues found a significant association between diarrhea and stunting (Kossmann et al., 2000). Another study indicated that severely stunted children had a three-fold increased risk of mortality from other infections including sepsis, meningitis, tuberculosis, hepatitis, and cellulitis (Prendergast and Humphrey, 2014). Moreover, Poor nutritional growth can severely affect the developing brain of the fetus or newborn, resulting in the failure to attain full developmental potential (Walker et al., 2011). In addition, stunting before the age of 2 years predicts poor cognitive and educational outcome in later childhood and adolescence (Walker et al. 2007; Black et al. 2013). Its educational and economic consequences affect the society at individual, household and community level. For instance, stunted children followed longitudinally in Brazil, Guatemala, India, The Philippines and South Africa were found to have completed nearly one year less schooling than non-stunted children (Adair et al. 2013). Similarly, a study of Guatemalan adults found that those who were stunted as children had less total schooling, lower test performances, lower household per capita expenditure and a higher likelihood of living in poverty (Hoddinott et al., 2013).

In the long-term, stunting between conception and two years of age is a greater risk for poor health and lower socioeconomic attainment throughout the lifetime (Prendergast et al., 2014).

Paradoxically, the metabolic syndrome, usually associated with over-nutrition, is more common in adults who experienced poor linear growth in early childhood compared to those who had healthy child growth (Prendergast et al., 2014). Regarding the economic consequences, the World Bank estimates indicate that a 1% loss in adult height due to childhood stunting is associated with a 1.4% loss in economic productivity (Shekar et al., 2006). Studies also found that stunted children earn 20% less when they become adults compared to non-stunted individuals (Grantham-McGregor et al., 2007). Concerning the learning capacity, stunted children are more likely to fall behind in schools, to learn lessons in future; thus, not fully contributing to the development of their nations (World Health Organization, 2013). As for the reproductive health, a study indicated that children born to stunted mother (height less than 145 cm) are at greater risk of dying than children of mothers with normal height (Ízaltin & Subramanian, 2010).

Globally in 2016, 22.9% or 154.8 million children under five years of age suffered from child stunting, defined by a low height-for-age (UNICEF, WHO, World Bank Group, 2017). In the same year, 87 million stunted children lived in Asia, 59 million in Africa and 6 million in the Latin American and Caribbean regions (UNICEF, WHO, World Bank Group). These global trends show that stunting affects large numbers of children worldwide. In Guinea, stunting is a large public health problem. The Demographic and Health Survey conducted in 2012 estimated the prevalence of child under-five stunting at 31% (Institut National de la Statistique/Guinée and ICF International, 2013).

Given its public health importance, the world health assembly in 2012 set an ambitious target of reducing stunting by 40 percent between 2010 and 2025 (Haddad et al., 2015). To help Guinean government be in line with this target, we aimed at identifying factors associated with growth faltering or stunting. This is particularly important given that The Republic of Guinea has experienced a public health crisis due to Ebola epidemic from 2014 to 2015, which led to deterioration in social and economic conditions as well as in health service delivery. This paper will, therefore, help to design and implement effective nutrition interventions and to inform policies.

Aim:

This study aimed to identify factors associated with moderate and severe stunting among children aged 0-59 months in Guinea.

CHAPTER II Literature Review

2.1 Country Profile

Guinea, officially known as the Republic of Guinea, is a country on the western coast of Africa. The country shares borders with Guinea-Bissau and Senegal in the north; Mali, Côte d'Ivoire in the east; Liberia and Sierra Leone in the south. The country is subdivided into 8 administrative regions including Conakry, Kindia, Boke, Mamou, Labe, Kankan, Faranah and N'zwerekore (fig 1). It had an estimated population of 11 663 627 in 2012 (GDHS, 2012) and an area of 245,860 square kilometers (94 927 sq. mi). Guinea's economy is largely dependent on agriculture and mineral production. It is the second largest producer of bauxite and has rich deposits of diamonds and gold.

The recent Ebola epidemic has severely disrupted an already weak health system in Guinea. Consequently, both community-based nutrition interventions and institution-based nutrition services were profoundly affected (Woodruff et al., 2018)

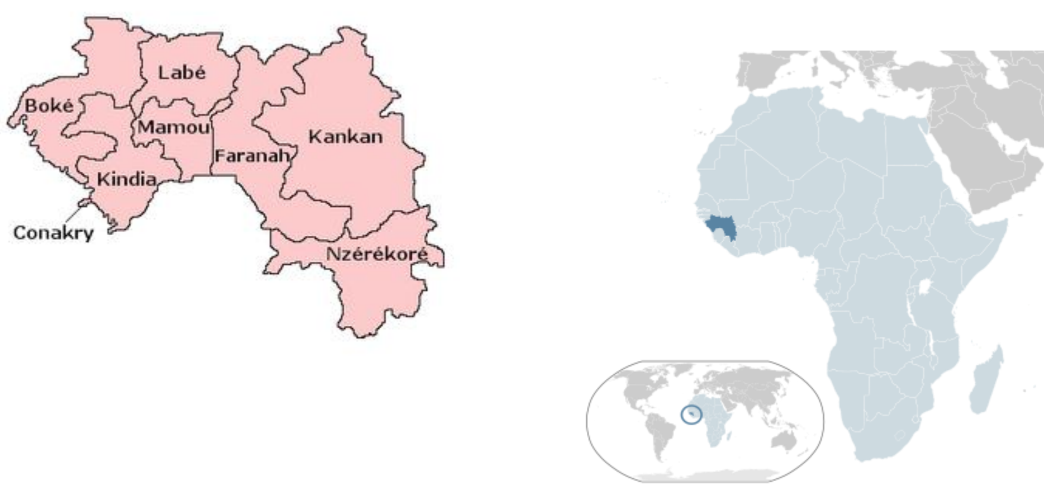

Fig 1 Source: https://en.wikipedia.org/wiki/File:Location_Guinea_AU_Africa.svg

2.2 Determinants of Child Stunting

This section reviews the theoretical and empirical literature on determinants of child stunting in developing countries. Causes of poor linear growth are complex, ranging from biological and social to environmental factors (Wamani et al., 2005). To address the complex inter-relationships between various risk factors, some authors have proposed the use of frameworks and models for studying and predicting the determinants of child nutrition outcome (Victora et al., 1997; Hien and Hoa 2009). Based on this framework, the determinants of child stunting are grouped into the following factors: inherent factors (child's age and sex), distal factors which include socio-economic level, intermediate factors (environmental and maternal factors), and proximate factors (child level factors).

2.2.1 Inherent factors. Child's age and sex

Previous research findings on stunting in Sub-Saharan Africa indicate that boys are more likely to be stunted than girls. For example, Wamani and colleagues conducted a study on sixteen demographic and health survey (DHS) in ten Sub-Saharan countries. The authors found that the prevalence and the mean Z-scores of stunting were consistently lower among females than amongst boys; however, the reason explaining this difference remains unclear (Wamani et al. 2007). Previous studies have explored the relationship between the age of the child and stunting. For example, in a study conducted by Kismul et al. (2018), the prevalence of stunting was higher in the age group of 36-47 months.

2.2.2 Distal factors. Socioeconomic status is usually measured by education, income, job position at an individual level. It can also be estimated by place of residence. A large and growing body of literature has investigated the impact of socioeconomic status on child stunting. Studies of variation in stunting prevalence across countries and between different populations within countries demonstrate the importance of socio-economic factors. For example, Black and colleagues investigated the prevalence of stunting among under-five year children incorporating seventy-nine countries. Their result showed that the prevalence of stunting among these children was 2.47 times higher in the poorest quintile of households compared to the richest one. (Black et al., 2013). Stunting prevalence is, therefore, a good indicator of inequalities in human development. (Prendergast et al. 2014). Regarding the role of mother's education, Schultz (1984) reported that educated mothers are more likely to earn higher incomes and to marry educated men, therefore enabling the children to live in a better environment, and allowing to provide better food and better health services relative to their uneducated counterparts (Schultz, 1984).

2.2.3 Intermediate factors.

2.2.3.1 Family size. The level of crowding in a house is not only a proxy for general social standing; but it also has a direct effect on mortality through the transmission of infectious diseases (Bernhardt, 1992). The study in Cameroon suggests that the hazards of health arise mainly from overcrowding, unhygienic methods of construction, inadequate and impure water supplies, and the arrangements of cooking and storage of food (Defo, 1997).

2.2.3.2 Drinking water and sanitation. Various studies have demonstrated the relationship between the household environmental conditions and the chance of child survival (Gaspari and Woolf, 1985; Preston and Van de Walle, 1978). In 1964, Johnson reported that two of the most important causes of poor health among people of developing countries rest on the inadequate provision for sewage disposal and contamination of drinking water (Johnson, 1964). The importance of clean drinking water in the dwelling is essential to child survival when breastfeeding is stopped, and the child is weaned. The protection against infection conferred by breastfeeding is no longer available, and the child is more exposed to infections. The improvement in the quality of water and the provision of sanitation facilities for safe disposal of human excreta is particularly crucial for the health of children

2.2.3.3 Mother's age at childbirth. Adolescent pregnancy has a well-established link with nutrition outcome and is of importance in Guinea where teenage pregnancy is common. In their study, Haidar et al. (2005) showed that children born to girls less than fifteen years old were significantly more likely to be stunted (Haidar et al. 2005).

2.2.3.4 Mother's nutritional status. Mothers with BMI less than 18.5 were more likely to have stunted children than mothers with BMI greater than 25 (Akombi et al., 2017). Several other studies showed that maternal BMI was an important risk factor associated with poor intrauterine growth and low birth weight; these in turn are known to be determinants of stunting in early childhood (Black et al., 2013).

2.2.3.5 Birth interval. A short birth interval could be risky if the mother's nutrient reserves become depleted, which could increase the risk of intrauterine growth retardation and adversely affect infant nutrition stores at birth and nutrient delivery via breastmilk. Aerts and colleagues (2004) argued that stunting was more likely with a previous birth interval of less than 24 months (Aerts et al. 2004).

2.2.4 Proximal factors

2.2.4.1 Diarrhea. Diarrhea has been consistently identified as the most important infectious disease determinant of stunting. (Black et al. 2013). For instance, a study conducted by Akombi and colleagues showed that **c**hildren who had a recent episode of diarrhea were more likely to have stunted growth when compared with children who had not. (Akombi et al., 2017).

2.2.4.2 Breastfeeding initiation. Timely initiation of breastfeeding is referred to as putting the newborn to breast either immediately or within an hour of birth (Fosu-Brefo and Arthur, 2015).

There are some benefits of early breastfeeding. Colostrum is rich in protective factors, and early initiation of breastfeeding ensures that infant receives colostrum. In their study, Stegn and colleagues concluded that timely initiation of breastfeeding is not only the easiest but also the most cost-effective intervention in improving the health of the newborn.

CHAPTER III Methods

3.1 Data Source

We analyzed data from the 2012 Guinea Demographic and Health Survey. The survey used a two-stage sampling method. The first stratum divided the countries into eight administrative regions. These domains were further stratified into urban and rural areas (second stratum). Households were then randomly sampled within each level proportionally to the actual distribution of the population. Details of the DHS methodology along with the country-specific one is available on the measure DHS website. Further information is found in Guinea DHS 2012 final report (in French) which can be freely downloaded from the measure DHS website (Institut National de la Statistique/Guinée and ICF International. 2013). Guinea Demographic and Health Survey is a large, nationally representative household-based survey, implemented to collect detailed information on fertility, knowledge and use of family planning methods, mother and child health. The main objective of the 2012 Guinea DHS was to provide up-to-date information to policymakers and program managers to help them evaluate and improve existing programs (ICF Macro, 2011). The data for this study was requested online from the Demographic and Health Survey website and an approval was given to download the dataset.

3.2 Study Design

A cross sectional study was conducted to find risk factors associated with childhood stunting.

3.3 Study Population

The DHS collected anthropometric data for all women and children younger than five years in the selected household. For this study, the data were restricted to weighted sample of **3176** children, which excluded children with extreme HAZ (HAZ above 6 SD or below -6SD), those with biologically implausible heights, and those who did not sleep last night at their home and those whose mothers were not interviewed.

3.4 Conceptual framework

There are several models to explain the determinants of child health. For this study, however, we used the framework from Hien and Hoa (Hien and Hoa, 2009). This framework is in line with the UNICEF conceptual framework describing determinants as tiers of interrelations (Levitt et al., 2009). The UNICEF framework clarifies how the problem of child malnutrition is related to factors at higher levels and thereby views the problem of malnutrition as a larger development problem (Black et al., 2008). Using the conceptual framework, we grouped the independent variables into distal, intermediate and proximal factors (fig. 1).

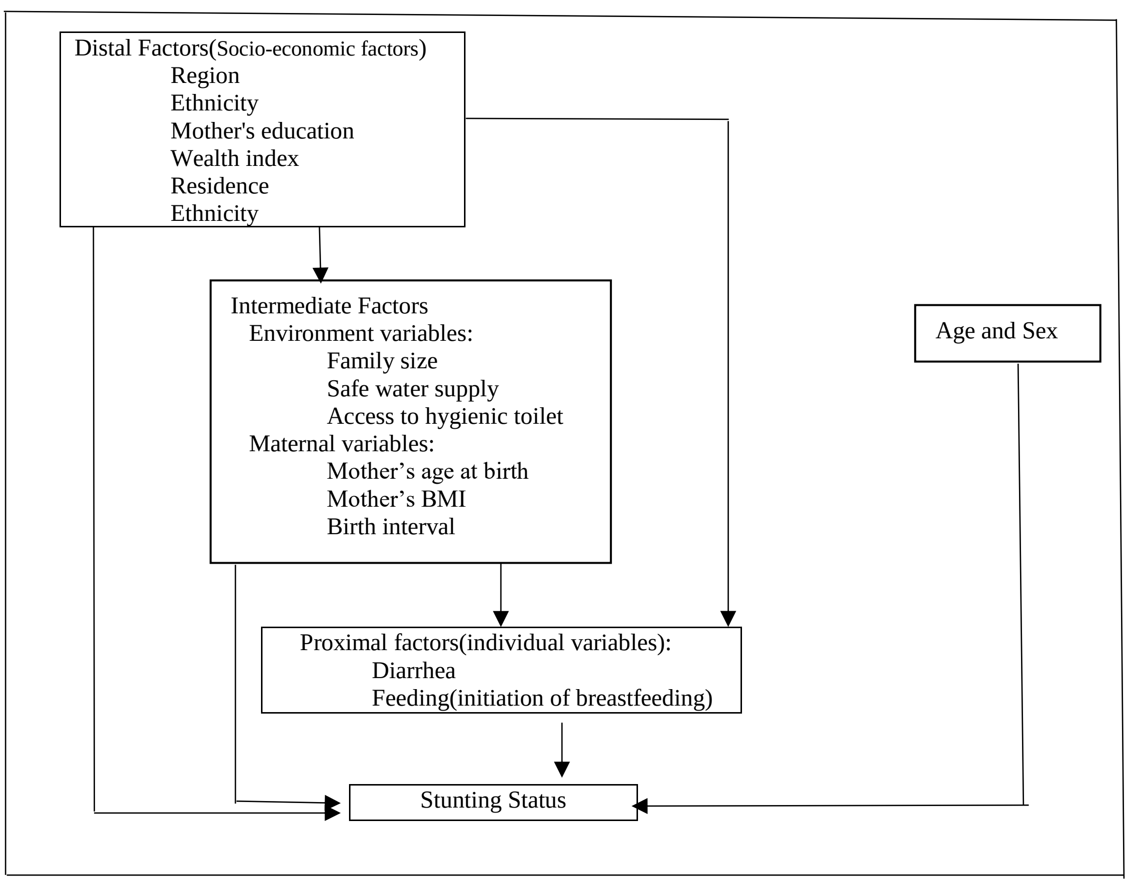

Fig 2: Conceptual hierarchical framework of the determinants of Stunting

3.4.1 Dependent variable.

Data regarding the height/length and weight were obtained for children below 59 months of age. Height-for-age index was calculated based on the WHO-Multicenter Growth Reference Study (MGRS). **Stunting** was defined as a Z-score of height for age index (HAZ) less than two standard deviation (<-2SD) of the median of the reference population**. Severe stunting** was considered as a HAZ <-3SD (World Health Organization, 2010; Bisits Bullen, 2011).

3.4.2 Independent Variables

Inherent factors

Child age. Age in months was grouped into less than 6 months, 6-8 months, 9-11 months, 12-17 months, 18-23 months, 24-35 months, 36-47 months, and 48-59 months.

Child gender. Child sex was self-reported as male and female.

Distal factors:

Mother's education. Educational level was put into three categories: No education, primary, secondary or *higher education.*

Wealth quintile. DHS categorized family wealth index into five categories including poorest, poorer, middle, richer, and richest.

Residence. Categorized into urban and rural area.

Regions. Guinea has eight administrative regions including Boke, Faranah, Kankan, Kindia, Labe, Mamou, N'zerekore and the capital city Conakry.

Ethnicity. Recoded into seven ethnic groups that include Soussou, Peulh, Malinke, Kissi, Toma, Guerze, and others.

Intermediate factors:

Family size. Recode into small (less than four members), Medium (five to eight members) and large (nine members or more).

Drinking water and sanitation: based on Core questions on drinking water and sanitation for household surveys developed by the World Health Organization and UNICEF, sanitation and the source of drinking water were categorized as follow:

*Hygienic toilets***.** Flush to piped sewer system, flush to septic tank, flush to pit latrine, ventilated improved pit latrine, pit latrine with slab, composting toilet.

Non-hygienic toilets: flush to somewhere else, pit latrine without slab/open pit, no facility/bush/field, bucket toilet, hanging toilet and other.

*Improved source or safe drinking water****:*** piped into dwelling, piped into yard/plot, public tap/standpipe, piped from the neighbor, tube well or borehole, protected well, protected spring, rainwater, and bottled water.

*Unimproved source or not safe drinking water***:** unprotected well, unprotected spring, River/dam /lake/ponds /stream/canal/irrigation channels, tanker truck.

Mother's age at childbirth. Categorized into less than 20 years, 20-34 years, and 35 years or more.

Mother's nutritional status**.** Based on the body mass index, categorized into thin (BMI <18.5 kg/m^2), normal (BMI between 18.5 and 24.9 kg/m^2), overweight or obese (BMI >=25.00 kg/m^2). Pregnant woman and breastfeeding mothers (previous two months) were excluded as the mother's initial BMI is influenced by pregnancy weight gain. (Dewey and Cohen, 2007).

Birth interval. Grouped into first birth, less than 24 months, 24-47 months, and 48 months or more.

Proximal factors:

Child health status. Coded as one if the child had diarrhea in the last two weeks and zero if not.

Breastfeeding initiation within the first hour of birth. Coded 1 if the child was breastfed within the first hour of the birth and 0 if not.

3.5 Data Analysis

Statistical Analysis System SAS (SAS Institute Inc., Cary, NC, USA) software program version 9.4 was used for all data analysis. Differences in stunting prevalence across background characteristics were tested using chi-square tests. We used SURVEYLOGISTIC procedure in SAS to take into account the hierarchical nature of the sampling design of our study. Analysis was based on the conceptual framework proposed by Hien and Hoa (2009). According to this model, socioeconomic variables may affect directly or act through intermediate factors. The overall effect of distal, intermediate and proximal variables were assessed the first time each level was entered into the model. In the first model, child's age, sex and the distal (socio-economic factors) factors were entered to assess their association with childhood stunting. A manual stepwise backward elimination method was conducted and factors significantly associated with the study outcome were retained. In the second model, the intermediate factors (environmental and maternal) factors were added to the significant factors from the first model and a backward elimination procedure was performed. In the third model, the proximal (child-level) factors were added to the significant factors form the first and second model.

. The place of residence (urban/rural) was removed in the model 1 due to its high correlation with wealth index. Result not shown. In addition, a multivariate multinomial logistic regressions analysis were applied to assess the effect of the socio-economic and demographic factors on the severity of stunting.

CHAPTER IV Results

4.1 Descriptive Analysis

The prevalence of childhood stunting was 31%, comprising of 17.6% moderate and 13.38% severe stunting (Fig 3). Of the children under study, forty-eight percent (48%) were female and fifty-two percent (52%) were male. The highest proportion of children was from Kankan region, followed by N'zerekore, Kindia, Conakry, Boke, Faranah, Labe and Mamou respectively. Regarding maternal education, more than half of the children had mother with no education while almost ten percent (10%) of the mothers had secondary or higher education. Twenty three percent (23%) of the children were from the poorest household, whereas fourteen percent (14%) were from the richest family. In terms of mother's nutritional status, more than half had mothers with normal body mass index (BMI between 18.5 and 24.9 kg/m^2) while eleven percent (11%) had mothers with body mass index less than 18.5 kg/m^2. One in three of the children were from Peulh ethnic group while one in six were from Soussou ethnic group. Twenty percent (20%) had mother less than twenty years whereas sixty five percent (65%) had mother between twenty and thirty four years. Forty four percent (44%) of the children were from households with five to eight members while forty two percent (42%) were from households with more than nine members. The most common source of drinking water was improved source (74%). Sixty three percent (63%) of the households did not have access to hygienic toilet. One in six children had diarrhea in the last two weeks. Eight two percent (82%) were breastfed within the first hour of the birth. As can be seen from table 1, all the variables are statistically significant at $p<0.05$ (bivariate analysis) except ethnicity, mother's age at childbirth and the proximal factors.

Table 1 Baseline characteristics and stunting among children age 0-59 months in Guinea

Children Characteristics	Sample **N=3176** N (%)	No stunting (HAZ[1]>=-2SD) **N(%)=2192(69%)** N (%)	Stunting (HAZ<-2SD) **N(%)=984(31%)** N (%)	p-value
Age				**<.0001**
Less than 6 months	367(11.55)	329(83.64)	38(10.36)	
6-8 months	215(6.77)	180(83.72)	35(16.28)	
9-11 months	135(4.25)	122(90.37)	13(9.63)	
12-17 months	382(12.03)	301(78.79)	81(21.21)	
18-23 months	277(8.72)	177(63.89)	100(36.11)	
24-35 months	584(18.39)	344(58.90)	240(41.10)	
36-47 months	602(18.95)	360(59.80)	242(40.20)	
48-59 months	614(19.34)	379(61.72)	235(38.28)	
Sex of Child				0.03
Male	1658(52.20)	1116(67.31)	542(32.69)	
Female	1518(47.80)	1076(70.88)	442(29.12)	
Distal factors				
Mother's education				
No education	2499(78.68)	1657(66.30)	842(33.70)	**<.0001**
Primary education	360(11.34)	270(75.00)	90(25.00)	
Secondary/Higher education	317(9.98)	265(83.59)	52(16.41)	
Wealth quintile				**<.0001**
Richest	443(13.94)	378(85.32)	65(14.68)	
Richer	628(19.77)	468(74.52)	160(25.48)	
Middle	635(19.99)	425(66.93)	210(33.07)	
Poorer	734(23.13)	443(60.35)	291(39.65)	
Poorest	736(23.17)	478(64.94)	258(35.06)	
Residence				**<.0001**
Urban	785(24.72)	647(82.42)	138(17.58)	
Rural	2391(75.28)	1545(64.62)	846(35.38)	
Region				**<.0001**
Conakry	386(12.15)	328(84.97)	58(15.03)	
Boke	328(10.32)	238(72.56)	90(27.44)	
Faranah	315(9.92)	218(69.20)	97(30.80)	
Kindia	479(15.08)	337(70.35)	142(29.65)	
Labe	275(8.65)	177(64.36)	98(35.60)	
Mamou	214(6.74)	124(57.94)	90(42.06)	
N'zerekore	585(18.44)	367(62.73)	218(37.27)	
Ethnicity				0.10
Soussou	530(17.05)	384(72.46)	146(27.54)	
Peulh	1027(33.05)	709(69.04)	318(30.96)	
Malinke	1073(34.53)	741(69.06)	332(30.94)	
Kissi	140(4.50)	85(60.72)	55(39.28)	
Toma	98(3.15)	61(62.25)	37(37.75)	
Guerze	164(5.27)	110(67.08)	54(32.92)	
Other	75(2.45)	51(68.00)	24(32.00)	
Intermediate factors				0.28
Mother's age at childbirth				
Less than 20 years	642(20.31)	435(67.75)	207(32.25)	
20-34 years	2051(64.92)	1408(68.65)	643(31.35)	
35 years or more	467(14.77)	336(71.95)	131(28.05)	

Note: 1 Height-for-age Z-score.
2 Excludes pregnant woman or woman with a birth in the 2 months preceding the survey.
3 Body mass index.
Level of significance: *** p-value <0.001; ** p-value <0.01; * p-value <0.05
P-value: comparing stunting and non-stunted Children.

Table 1 Baseline characteristics and stunting among children age 0-59 months in Guinea (continued)				
Mother's nutritional status[2]				**<.0001**
Thin(BMI[3]<18.5)	297(10.99)	178(59.93)	119(40.07)	
Normal(BMI 18.5-24-9)	1947(72.06)	1336(68.62)	611(31.38)	
Overweight/Obese(BMI>=25)	458(16.95)	351(76.63)	107(23.37)	
Birth interval				**<.0001**
48 months or more	682(21.49)	508(74.48)	174(25.52)	
24-47 months	1525(48.01)	1031(67.60)	494(32.40)	
Less than 24 months	273(8.59)	158(57.87)	115(42.13)	
First birth	696(21.91)	495(71.12)	201(28.88)	
Family size				**.0001**
Small(<= 4 members)	434(13.66)	305(70.27)	129(29.73)	
Medium (5-8 members)	1411(44.42)	1021(72.36)	390(27.64)	
Large(>9 members)	1331(41.92)	866(65.06)	465(34.94)	
Access to safe drinking water				**<.0001**
No	815(25.61)	505(61.96)	310(38.04)	
Yes	2357(74.39)	1684(71.45)	673(28.55)	
Access to hygienic toilet				**<.0001**
No	1999(62.94)	1283(64.18)	716(35.82)	
Yes	1177(37.06)	909(77.24)	268(22.76)	
Proximal factors				
Child had diarrhea				0.34
No	2583(83.59)	1787(69.19)	796(30.81)	
Yes	507(16.41)	340(67.07)	167(32.93)	
Breastfeeding within first hour				0.92
No	384(17.25)	275(77.62)	109(28.38)	
Yes	1841(82.75)	1320(71.71)	521(28.29)	

Note:
1 Height-for-age Z-score.
2 Excludes pregnant woman or woman with a birth in the 2 months preceding the survey.
3 Body mass index.
Level of significance: *** p-value <0.001; ** p-value <0.01; * p-value <0.05

4.2 Multivariate Analysis

4.2 Multivariate Logistic Regression Analysis. As shown in table 2, child age and sex were significantly associated with increased odds of stunting. The odds of stunting among male children was 1.22 times the odds among female children. For the age group, children aged 12-17 months, 18-23 months, 24-35 months, and 48-59 months were more likely to be stunted compared to those less than 6 months of age.

At the region level, children residing in Mamou were more likely to be stunted (adjusted OR=2.22 95% CI 1.20, 4.12) compared to those living in Conakry. Being from the middle, poorer and poorest quintile was a risk factors associate with stunting with the odds ratios of 2.08 (95% CI 1.11, 5.77), 3.05(95% CI 1.61, 5.77) and 2.56 (95% CI 1.35, 4.84) respectively.

As can be seen in model 2, Compared to children with birth interval of more than 48 months, children with less than 24 months birth interval had significantly higher odds of stunting [adjusted OR=1.56 95%CI 1.03-2.40]. Regarding the mother's nutritional status, children from thin mothers (BMI<=18.5) had higher odds compared to children whose mother had normal body mass index (adjusted OR=1.55 95% CI 1.12, 2.15).

However, none of the variables (history of diarrhea and breastfeeding initiation) was found to be significantly associated with stunting at child level in model 3.

Table 2 Multivariate Logistic Regression Analysis of association between stunting and under-five Children background characteristics Guinea 2012.

Characteristics	Model 1	Model 2	Model 3
	Adjusted OR (95%CI)	Adjusted OR (95%CI)	Adjusted OR (95%CI)
Age			
Less than 6 months	1.00	1.00	1.00
6-8 months	1.77(0.96-3.24)	1.50(0.78-2.87)	1.54(0.78-3.036)
9-11 months	0.974(0.40-2.35)	0.94(0.37-2.37)	1.03(0.40-2.63)
12-17 months	2.488(1.54-4.00)***	2.33(1.34-3.72)**	2.49(1.49-4.13)***
18-23 months	5.399(3.23-9.01)***	5.31(3.09-9.13)***	5.75(3.37-9.79)***
24-35 months	6.82(4.37-10.63)***	6.53(4.07-10.47)***	8.55(5.01-14.60)***
36-47 months	6.425(4.08-10.09)***	5.69(3.43-9.44)***	8.14(4.66-14.22)***
48-59 months	5.684(3.70-8.71)***	5.68(3.54-9.10)***	5.25(2.88-9.58)***
Sex of Child			
Female	1.00	1.00	1.00
Male	1.22(1.02-1.46)*	1.26(1.04-1.55)*	1.26(0.95-1.68)
Distal factors			
Wealth quintile			
Richest	1.00	1.00	1.00
Richer	1.50(0.82-2.74)	1.55(0.89-2.70)	2.3(1.11-4.72)*
Middle	2.08(1.11-3.90)*	2.95(1.07-3.58)*	2.39(1.12-5.13)*
Poorer	3.05(1.61-5.77)***	2.91(1.60-5.29)***	3.31(1.53-7.18)**
Poorest	2.56(1.35-4.84)**	2.37(1.29-4.37)**	3.49(1.60-7.65)**
Region			
Conakry	1.00	1.00	1.00
Boke	1.03(0.53-1.97)	0.94(0.53-1.66)	0.72(0.33-1.56)
Faranah	1.22(0.65-2.27)	1.17(0.65-2.08)	0.94(0.43-2.04)
Kankan	1.29(0.71-2.33)	1.16(0.67-2.02)	0.88(0.41-1.85)
Kindia	1.19(0.67-2.12)	1.07(0.61-1.88)	0.83(0.39-1.76)
Labe	1.59(0.84-3.02)	1.36(0.73-2.53)	1.01(0.46-2.21)
Mamou	2.22(1.20-4.12)*	2.05(1.12-3.75)*	1.59(0.71-3.57)
N’zerekore	1.60(0.90-2.86)	1.53(0.89-2.62)	1.07(0.51-2.24)
Intermediate factors			
Birth interval			
48 months or more		1.00	1.00
24-47 months		1.15(0.82-1.63)	1.42(0.99-2.03)
Less than 24 months		1.56(1.03-2.40)*	1.62(0.96-2.72)
First birth		1.16(0.82-1.64)	1.24(0.85-1.81)
Mother’s nutritional status[2]			
Normal(BMI 18.5-24-9)		1.00	1.00
Thin(BMI[3]<18.5)		1.55(1.12-2.15)**	1.22(0.82-1.82)
Overweight/Obese(BMI>=25)		0.86(0.64-1.14)	0.74(0.49-1.11)
Access to safe drinking water			
Yes		1.00	1.00
No		1.12(0.88-1.43)	1.21(0.91-1.61)
Proximal factors			
Child had diarrhea			
No			1.00
Yes			0.89(0.63-1.26)
Breastfeeding within first hour			
Yes			1.00
No			1.06(0.72-1.57)

[2] Excludes pregnant woman or woman with a birth in the 2 months preceding the survey.

[3] Body mass index.

Level of significance: *** p-value <0.001; ** p-value <0.01; * p-value <0.05

4.2.2 Multinomial logistic regression. Taking into account the severity of stunting, table 3 1 shows that age and wealth quintile had significant effect on moderate and severe stunting. The sex of the child was only related to severe stunting while the regions had significant association with moderate stunting. The odds of moderate stunting among children in Mamou region was 2.17 times the odds of the children from Conakry. Similarly the odds of moderate stunting among children residing in N'zerekore was 2.05 times the odds of children from Conakry. Sex is only significantly associated with severe stunting in the multinomial model (adjusted OR 1.37 95% CI 1.05, 1.79). Access to safe drinking water which was not significant in the multivariate analysis became related to severe stunting (adjusted OR 1.4395% CI 1.06, 1.93) in model 3 2

Table 3 1 Multinomial Logistic Regression Analysis of the effect age, sex, and the distal factors on moderate and severe stunting versus normal growth among under-five Children in Guinea 2012.

Characteristics	Moderate Stunting versus Normal growth	Severe Stunting versus Normal growth
Age		
Less than 6 months	1.00	1.00
6-8 months	1.50(0.73-3.09)	1.64(0.51-5.19)
9-11 months	0.46(0.13-1.64)	2.61(0.76-8.95)
12-17 months	2.16(1.23-3.79)**	3.31(1.21-9.07)*
18-23 months	3.65(1.88-7.09)***	11.43(4.69-27.81)***
24-35 months	6.36(3.42-11.80)***	14.28(5.49-37.12)***
36-47 months	6.09(3.26-11.38)***	13.56(5.21-35.25)***
48-59 months	3.36(1.65-6.83)***	10.28(3.65-28.92)***
Sex of Child		
Female	1.00	1.00
Male	1.12(0.9-1.39)	1.37(1.05-1.79)*
Distal factors		
Wealth quintile		
Richest	1.00	1.00
Richer	1.23(0.71-2.13)	2.10(0.8-5.49)
Middle	1.74(0.98-3.09)	2.87(1.04-7.90)*
Poorer	2.04(1.13-3.67)*	5.58(2.02-15.39)**
Poorest	2.10(1.18-3.75)*	3.63(1.29-10.17)*
Regions		
Conakry	1.00	1.00
Boke	1.14(0.61-2.14)	0.84(0.30-2.32)
Faranah	1.5(0.80-2.81)	0.86(0.33-2.22)
Kankan	1.37(0.74-2.53)	1.12(0.44-2.83)
Kindia	1.48(0.83-2.63)	0.84(0.34-2.08)
Labe	1.56(0.83-2.92)	1.50(0.56-4.01)
Mamou	2.17(1.16-4.05)*	2.14(0.85-5.37)
N'zerekore	2.05(1.15-3.66)*	1.08(0.44-2.65)

Level of significance: *** p-value <0.001; ** p-value <0.01; * p-value <0.05

Table 3 2 Multinomial Logistic Regression Analysis of the effect age, sex, the distal and intermediate factors on moderate and severe stunting versus normal growth among under-five Children in Guinea 2012.

Characteristics	Moderate Stunting versus Normal growth	Severe Stunting versus Normal growth
Age		
Less than 6 months	1.00	1.00
6-8 months	1.31(0.64-2.67)	2.07(0.70-6.10)
9-11 months	0.37(0.11-1.25)	2.80(0.80-9.77)
12-17 months	1.93(1.10-3.37)*	3.17(1.20-8.36)*
18-23 months	3.6(1.84-7.02)***	10.69(4.48-25.49)***
24-35 months	4.71(2.76-8.05)***	12.07(5.03-28.99)***
36-47 months	4.59(2.65-7.94)***	9.07(3.70-22.24)***
48-59 months	4.27(2.55-7.13)***	4.27(2.55-7.13)***
Sex of Child		
Female	1.00	1.00
Male	1.16(0.91-1.48)	1.44(1.07-1.95)
Distal factors		
Wealth quintile		
Richest	1.00	1.00
Richer	1.32(0.72-2.42)	2.13(0.92-4.93)
Middle	1.72(0.89-3.31)	2.62(1.07-6.43)*
Poorer	2.21(1.14-4.28)*	4.76(1.99-11.43)***
Poorest	2.07(1.08-3.96)*	3.22(1.27-8.15)*
Regions		
Conakry	1.00	1.00
Boke	1.14(0.59-2.17)	0.65(0.27-1.56)
Faranah	1.36(0.69-2.66)	0.86(0.37-2.00)
Kankan	1.27(0.67-2.38)	0.95(0.40-2.23)
Kindia	1.37(0.73-2.58)	0.67(0.28-1.59)
Labe	1.35(0.69-2.63)	1.24(0.48-3.14)
Mamou	2.10(1.06-4.14)	1.80(0.75-4.31)
N'zerekore	1.84(1.01-3.33)	1.08(0.48-2.45)
Birth interval		
48 months or more	1.00	1.00
24-47 months	0.94(0.62-1.43)	1.61(1.05-2.46)*
Less than 24 months	1.17(0.68-2.03)	2.44(1.41-4.24)**
First birth	1.03(0.67-1.57)	1.45(0.94-2.22)
Mother's nutritional status[2]		
Normal(BMI 18.5-24-9)	1.00	1.00
Thin(BMI[3]<18.5)	1.63(1.16-2.30)**	1.45(0.92-2.29)
Overweight/Obese(BMI>=25)	0.83(0.58-1.18)	0.89(0.58-1.39)
Access to safe drinking water		
Yes	1.00	1.00
No	0.93(0.69-1.27)	1.43(1.06-1.93)*

[2] Excludes pregnant woman or woman with a birth in the 2 months preceding the survey.

[3] Body mass index.

Level of significance: *** p-value <0.001; ** p-value <0.01; * p-value <0.05

Table 3 3 Multinomial Logistic Regression Analysis of the effect age, sex, the distal , intermediate and proximal factors on moderate and severe stunting versus normal growth among under-five Children in Guinea 2012.

Characteristics	Moderate Stunting versus Normal growth	Severe Stunting versus Normal growth
Age		
Less than 6 months	1.00	1.00
6-8 months	1.50(0.73-3.09)	1.64(0.51-5.19)
9-11 months	0.46(0.13-1.64)	2.61(0.76-8.95)
12-17 months	2.16(1.23-3.79)**	3.31(1.21-9.07)*
18-23 months	3.65(1.88-7.09)***	11.43(4.69-27.81)***
24-35 months	6.36(3.42-11.80)***	14.28(5.49-37.12)***
36-47 months	6.09(3.26-11.38)***	13.56(5.21-35.25)***
48-59 months	3.36(1.65-6.83)***	10.28(3.65-28.92)***
Sex of Child		
Female	1.00	1.00
Male	1.1(0.78-1.53)	1.52(1.07-2.18)*
Distal factors		
Wealth quintile		
Richest	1.00	1.00
Richer	1.85(0.86-4.00)	3.43(0.97-12.12)
Middle	1.73(0.76-3.90)	4.36(1.16-16.33)*
Poorer	2.13(0.92-4.90)	6.98(1.82-26.80)**
Poorest	2.23(0.96-5.15)	7.39(1.90-28.72)**
Regions		
Conakry	1.00	1.00
Boke	1.01(0.38-2.61)	0.39(0.11-1.43)
Faranah	1.39(0.53-3.67)	0.47(0.14-1.53)
Kankan	1.20(0.47-3.08)	0.50(0.15-1.59)
Kindia	1.17(0.45-3.03)	0.45(0.14-1.47)
Labe	1.19(0.46-3.06)	0.69(0.20-2.43)
Mamou	2.02(0.74-5.47)	1.02(0.30-3.38)
N'zerekore	1.57(0.62-3.93)	0.56(0.17-1.79)
Birth interval		
48 months or more	1.00	1.00
24-47 months	1.20(0.76-1.88)	1.80(1.15-2.84)*
Less than 24 months	1.29(0.66-2.52)	2.18(1.09-4.34)*
First birth	1.09(0.66-1.82)	1.46(0.88-2.41)
Mother's nutritional status[2]		
Normal(BMI 18.5-24-9)	1.00	1.00
Thin(BMI[3]<18.5)	1.22(0.75-1.97)	1.24(0.74-2.07)
Overweight/Obese(BMI>=25)	0.69(0.41-1.18)	0.80(0.45-1.4)
Access to safe drinking water		
Yes	1.00	1.00
No	1.10(0.78-1.56)	1.37(0.95-1.98)
Proximal factors		
Child had diarrhea		
No	1.00	1.00
Yes	1.00(0.66-1.49)	0.76(0.48-1.22)
Breastfeeding within first hour		
Yes	1.00	1.00
No	1.32(0.76-2.28)	0.83(0.53-1.30)

[2] Excludes pregnant woman or woman with a birth in the 2 months preceding the survey.
[3] Body mass index.
Level of significance: *** p-value <0.001; ** p-value <0.01; * p-value <0.05

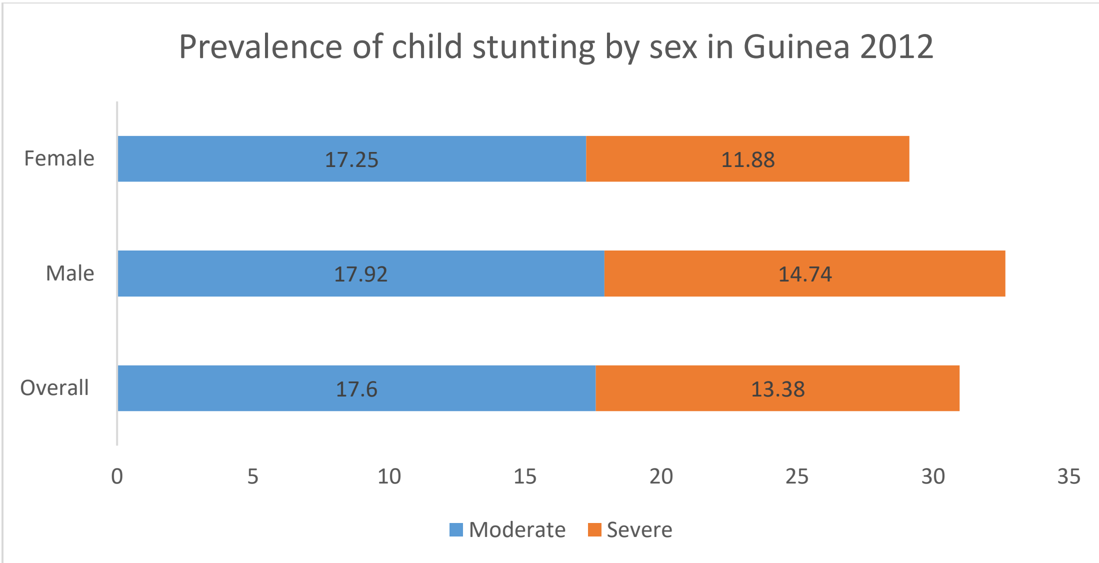

Fig 3 Prevalence of child stunting by sex in Guinea 2012.

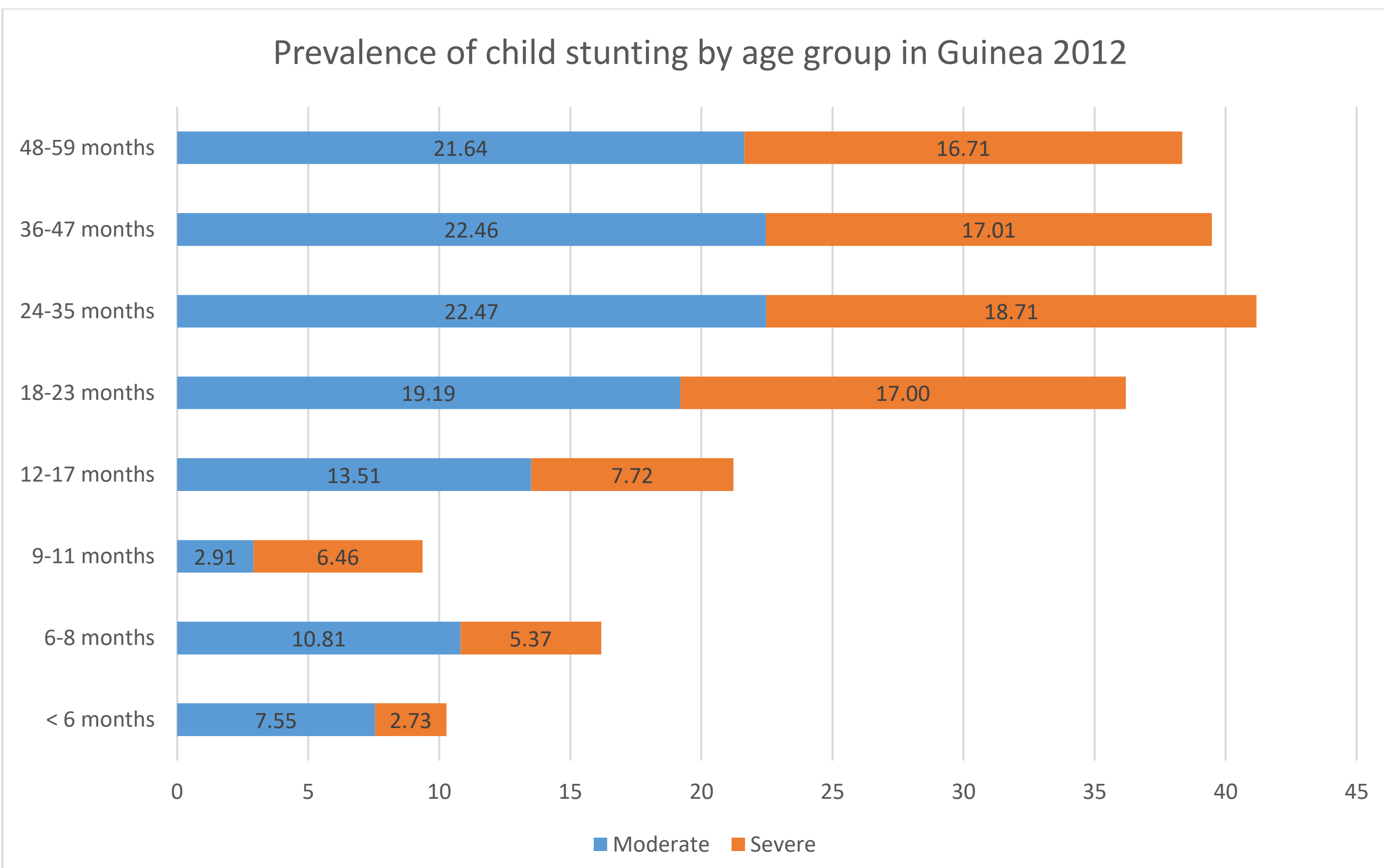

Fig 4 Prevalence of child stunting by age group in Guinea 2012.

CHAPTER V Discussion and Conclusion

4.1 Discussion

In the current study, the prevalence of 31 % for stunting was ranked by the World Health Organization as the "high level" worldwide. One in every three children being stunted is a serious public health problem. In our study, we applied a conceptual framework to identify determinants of childhood stunting in Guinea. Our investigation revealed that male children were at higher risk of being stunted or severely stunted compared to females. The odds of severe stunting among boys were 1.37 times the odds among girls. Also, the prevalence was higher in boys (32.69%) than in girls (29.12%). Wamani et al. (2007) who analyzed data from 16 demographic Health Survey (DHS) in 10 Sub-Saharan African countries also reported this finding. Their results indicated that the prevalence of stunting was higher in boys (40%) than in girls (36%) in the pooled analysis (Wamani et al. 2007).

We found that child's age was a consistent factor associated with stunting. Growth faltering was observed as the age of the child increased. This finding could be explained by the challenge of successfully transitioning from exclusive breastfeeding to adequate complementary feeding. Also, the increase in child stunting with age could be as result of the increased interaction of the older child with the environment which may lead to increased exposure to childhood diseases either through consumption of contaminated food, drinking water from unimproved sources or poor environmental sanitation (Akombi et al. 2017).

In the present study, children from the poorest, poorer or middle households were more likely to be stunted compared to those from the richest or richer households. This could be explained by the effect of wealth in the purchase of food that promotes the health of children. Various studies have observed a positive association between low income and stunting. For the region, Mamou had the highest odds of stunting followed by N'zerekore region. Findings from other studies have also highlighted within-country variation in term of the prevalence of stunting. For example, Mohsena & Nicholas (2015) conducted a study using The Bangladesh Demographic and Health Surveys. The authors used multinomial logistic regression to assess the inequalities in maternal and child nutrition status among the six administrative divisions in Bangladesh. Their findings revealed that stunting prevalence in children under five years varied across the six administrative divisions with Sylhet division having the highest prevalence of childhood stunting.

In our analysis, children born to mothers of low BMI (less than 18.5 kg/m^2) were more likely to be stunted compared to those born to mothers with normal BMI. Past studies showed that maternal BMI is a significant risk factor associated with poor intrauterine growth and low birth weight; these, in turn, are known to be determinants of stunting in early childhood. (Black et al., 2013). A similar cross-sectional study conducted in Bangladesh reported that mother's BMI which is an indicator of the mother's nutritional status was significantly associated with stunting. (Rahman & Chowdhury2007).

Another important finding was that short birth interval was associated with higher odds of stunting. This finding was also reported by Ikeda and Shibuya (2013).

However, our study did not show an association between stunting and the following factors: mother's age, breastfeeding initiation, history of diarrhea, and family size.

Strengths and Limitation:

The main strengths of our study were that it used a nationally representative survey data and applied appropriate statistical adjustment for the cluster sampling design in the analysis. One key limitation, however, was that we could not establish the cause and effect relationships due to the cross-sectional nature of the study design. Another limitation was that residual confounding from unmeasured covariates could not be ruled out. The study could be improved by considering other predictors such as childbirth weight.

4.2 Conclusion

The factors associated with childhood stunting are multifactorial and interdependent. Hence, there is a need to adopt a multi-strategy community-based approach that targets the distal and intermediate determinants of child under-nutrition. Such approach should include counseling sessions for mothers with the aim of improving maternal nutrition and family planning. Public health campaigns should increase awareness on the importance of proper sanitation and hygiene practice. Further intervention to improve child under-nutrition should also focus on cash transfer initiatives to address poverty and increase food access. These strategies will yield a more sustainable improvement in child nutrition in Guinea; thereby setting the country on the path to achieving the World Health Organization global nutrition target by 2025.

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