multivariate binary logistic regression were used to examine the association between stunting and selected environmental, maternal-socio-demographic and child level factors. Statistical significance was set at P<0.005.

Results: Of the 7045 under-five children, 2479 (34.9%) were found to be stunted. Stunting was higher among male children as compared to female children (38.5% vs 31.3% respectively). The factors associated with stunting were childs: sex; age; birth size; breastfeeding; residence; maternal education; wealth index; twin births and the birth interval among siblings. Children born to mothers whose previous birth interval is less than 24 months (aOR= 1.34 95%CI: 1.13-1.58; P<0.001), children from poor households (aOR= 1.65 95%CI: 1.32-2.08; P<0.001), twin births (aOR=2.65 95%CI: 1.61-4.36; P<0.001), children whose mothers had primary education (aOR=1.16 95%CI 1.00-1.35; P=0.046), children coming from households whose source of drinking water was non-improved (aOR= 1.30 95%CI: 1.09-1.5; P=0.003), child not breastfed (aOR= 1.20 95%CI: 1.04-1.38; P=0.015) were more likely to be stunted.

Conclusion: The study established that the maternal and child factors of stunting. Therefore, to reduce the burden of stunting interventions that can address these factors are required such as community-based education and targeted nutritional interventions and strengthening the health system for improving child health through prioritising maternal and child by addressing poverty and increase food access is mostly needed.

Keywords: Children, Stunting, Zambia Demographic and Health Survey

Introduction

Stunting or low Height-for-Age z-score (HAZ) continues to be a public health problem affecting growth potential in children. Child stunting refers to a child who is too short for his or her age and is the result of chronic or recurrent malnutrition [1]). Stunting is a contributing risk factor to child mortality and is also a marker of inequalities in human development [2, 3]. Stunting is more prevalent in developing countries such as many countries in Asia and Africa stunting. According to the United Nations, 35.6% and 29.1% of children in Eastern and Southern Africa, under 5 years of age are stunted, respectively [1, 4]. Over the past years, the prevalence of stunting has gradually reduced but generally progress is unsatisfactory as countless children are at risk. At national level stunting prevalence has persistently remained above 35% among children below the age of 5 with Northern Province recording the highest prevalence at 46% [5].Stunted growth is as the result of several prevailing factors vis-à-vis; poor maternal health and nutrition, inadequate infant and young child feeding practices, infection, health, water and sanitation services, demographic and socio-economic factors. In terms of maternal health and nutrition, these include: maternal nutritional and health status before, during and after pregnancy that influences a child's early growth and development, commencement in the womb. Infant and young child feeding practices that contribute to stunting include suboptimal breastfeeding (specifically, non-exclusive breastfeeding) and balancing feeding that is limited in quantity, quality and variety [6].

Stunting is a huge drain on economic productivity and development because resources that can be prorated to other infrastructural development are altered to nutrition and feeding programs, and sensitization of mothers on good feeding practices. Economists estimate that stunting can reduce a country's Gross Domestic Product (GDP) by up to 3% [7]. More so, stunting leads to short adult height, long-term effects on individuals and societies; including diminished cognitive and physical development, reduced productive capacity and poor health, and an increased risk of degenerative diseases such as diabetes. In Zambia, evidence regarding factors associated with stunting has been very low and limited. Therefore, we conducted this study to identify socio-economic and environmental factors that were associated with stunting among children aged 0-59 months in Zambia using 2018/2019 Zambia Demographic Health Survey.

Methods

Study design: The study extracted data for under-five children from the 2018/2019 Zambia Demographic Health Survey dataset. The dataset provided data on child anthropometric measurements, socio-economic variables, food types and other factors. These factors were selected based on United Nations Children's Emergency Fund (UNICEF) framework of the factors that determine nutritional status [2]. The 2018/2019 Zambia Demographic Health Survey was a cross sectional which was a nationally representative probability sample of women in the reproductive age 15 to 49 and men 15 to 59 years [5].

Sampling and data collection methods: The 2018 ZDHS followed a stratified two-stage sample design [5]. The first stage involved selecting sample points (clusters) consisting of EAs. EAs were selected with a probability proportional to their size within each sampling stratum. A total of 545 clusters were selected. The second stage involved systematic sampling of households. A household listing operation was undertaken in all of the selected clusters. During the listing, an average of 133 households were found in each cluster, from which a fixed number of 25 households were selected through an equal probability systematic selection process, to obtain a total sample size of 13,625 households. Results from this sample are representative at the national, urban and rural, and provincial levels. All women aged 15-49 and men aged 15-59 who were either permanent residents of the selected households or visitors who stayed in the households the night before the survey were eligible to be interviewed.

Data Management: The ZDHS dataset was de-identified to prevent a person's identity from being linked with information. First, a binary variable was created defining stunting as "stunted" (Z-score less than -2 SD) and "not stunted" (Z-score equal to and greater than -2 SD). Based on literature and guidance from the conceptual framework the study included the following independent variables: child sex, child age, immunisation, antenatal care during pregnancy, place of delivery, maternal education, age of mother, mother's previous birth interval, birth size, current marital status, twin's births, birth intervals among siblings, number of children ever born, breastfeeding, residence, wealth index, and quality of source of drinking water. For the quality of source of drinking water, a variable was created categorising the sources as either being improved (piped water, protected well and spring, bottled water and rainwater) and non-improved (unprotected well and spring, tanker, surface water and other).

Statistical Analysis: Statistical analysis was performed using Stata version 14 (StataCorp, College Station, Texas, USA). Pearson's Chi-Square test (measure of relationship between two categorical variables) was used to explore relationships between prevalence of stunting and the independent variables. We calculated frequencies, proportions, crude odds rations and adjusted odds ratios (aOR). The analysis was weighted as it is standard for the DHS data to be weighted in order to account for complex study designs [5]. Only predictors with significant at $P = 0.20$ were considered for multiple logistic analysis. The final model was determined forward stepwise technique. Statistical significance was set at $P<0.05$.

Ethical approval: Institutional authorization was obtained from University of Lusaka, School of Medicine & Health Sciences Research Ethics Committee (protocol#: IORG0010092/ MPH19113810). The study was further approved by the National Health Research Authority (protocol #: NHRA00007/09/01/2021). As this study used secondary anonymised data, the issue of informed consent did not apply.

Results

Background characteristics of children

The characteristics of children and prevalence of stunting is shown in **Table 1**. Fifty one percent of children were female and the rest were male. Eleven percent of children were younger than six months and the rest were older than six months. Majority of children lived in rural.

Proportion of stunting by background characteristics

Table 1 shows that, 41.7% of children aged 12-23 months are stunted ($p<0.001$). Prevalence increased with increase in age. Disaggregation of this data by sex shows that male children are more stunted (38.5%) compared to female children (31.3%) ($p<0.001$). First born children are less likely to be stunted compared to children who are born as 1st multiple and 2nd multiple twins: 38.8% and 44.2% respectively ($p<0.001$).

Further, stunting increases with decreasing reported size at birth: 47.8% of children born small (very small/smaller than average) are stunted compared to those born with average and large size (very large/larger than average) 45.9% and 34.7%% respectively ($p<0.001$). Those children not immunized are slightly likely to be stunted compared to children fully immunized (35.5% and 34.7 respectively: $p=0.0692$).

Stunting in children was high among mother's aged 15–24 (36.4%: $p=0.446$). Children in rural areas were likely to be more stunted (35.4%) compared to children in urban areas (33.7%; $p=0.282$). Disaggregation by province shows that, Northern had the highest prevalence of children stunted 45.5% followed by Luapula 44.8% ($p<0.001$).

Children whose mothers had attained secondary and higher education are less likely to be stunted 31.4% compared with children whose mothers had less education; (no education 38.6% and primary 32.9%; $p<0.001$). In the same way, children in households with wealth index described as poor are more likely to be stunted (37.9%) compared to those whose households are or were classified as belonging to the richer quintile 31.1% or middle (32.8%; $p<0.001$).

Stunting was slightly higher among children whose mother reported their marital status as "never married" (35.9%) compared to those mother's reporting ever married (34.8%), although this was not statically significant ($p=0.653$).

By parity, stunting was more slightly pronounced in mother's reporting to have had 4-7 children ever born (35.1%) than those with 8 and above children 34.9% and those with 1-3 children 34.7%: $p=0.953$). The findings further shows that, children whose mothers delivered at home were likely to be stunted (37.6%) than those whose mothers delivered at a healthy facility (34.3%: p=0.173).

Children from households whose source of drinking water was improved (34.0%) were less likely to be stunted compared to children from households whose source of drinking water was poor (40%: p=0.005) and this is attributed to the fact that non-improved water sources may be contaminated which may increase risk of infection such as diarrhoea.

Among the children who are stunted, 32.2% were currently being breastfed during the time of the survey compared with 37.6% who were not (p<0.001). Children whose mothers did not go for antenatal (40.9%) were likely to be stunted compared to children whose mothers went for antenatal less than four visits, and four and more visits (33.9% and 34.7% respectively: p=0.307).

About 41.5% of the children whose mothers previous birth interval is less than 24 months are stunted compared with 33.7% whose mothers previous birth interval is 24 or more (p<0.001).

Table I: Proportion of stunting by background characteristics

Background Characteristics	**Total n (%)**	**Stunting**		**P-value**
		Not Stunted	**Stunted**	
Total	7, 045	4,566 (65.1)	2, 479 (34.9)	
Child Age in Months				
<6	773 (10.9)	611 (81.1)	162 (18.6)	
6-11	717 (10.1)	532 (75.0)	185 (25.0)	<0.001
12-23	1499 (21.1)	880 (58.3)	619 (41.7)	
24-59	4056 (57.8)	2543 (62.8)	1513 (37.2)	
Child Sex				
Male	3477 (49.4)	2142 (61.5)	1335 (38.5)	<0.001
Female	3568 (50.6)	2424 (68.7)	1144 (31.3)	
Twins Birth				
Singe Birth	6847 (97.5)	4477 (65.8)	2370 (34.2)	
1st of multiple	95 (1.2)	41 (38.8)	54 (61.2)	<0.001
2nd of multiple	103 (1.3)	48 (44.2)	55 (55.8)	
Child Breastfeeding				
Yes	3643 (51.1)	2425 (67.8)	1218 (32.2)	<0.001
No	3402 (48.9)	2141 (62.4)	1261 (37.6)	
Child Size				
Large	1717 (23.4)	1213 (70.8)	504 (29.2)	
Average	4359 (63.5)	2834 (65.3)	1525 (34.7)	<0.001
Small	774 (10.4)	399 (52.2)	375 (47.8)	
Immunisation				
Fully Immunised	5756 (81.8)	3726 (65.3)	2030 (34.7)	p=0.692
Not Immunised	1289 (18.2)	840 (64.5)	449 (35.5)	
Maternal Age				
15-24	2283 (32.4)	1457 (63.6)	826 (36.4)	

25-29	1809 (25.7)	1177 (65.5)	632 (34.5)	p=0.446
30-39	2393 (34)	1570 (66.1)	823 (33.9)	
40-49	560 (8.0)	362 (65.8)	198 (34.2)	
Residence				
Urban	1950 (32.6)	1296 (66.3)	654 (33.7)	p=0.282
Rural	5095 (67.4)	3270 (64.6)	1825 (35.4)	
Region				
Central	648 (8.0)	428 (66.0)	220 (34.0)	
Copperbelt	645 (12.2)	437 (70.1)	208 (29.9)	
Eastern	875 (14.2)	584 (67.7)	291 (32.2)	
Luapula	816 (9.4)	444 (55.2)	372 (44.8)	
Lusaka	738 (14.8)	474 (62.4)	264 (37.6)	
Muchinga	643 (6.3)	437 67.5)	206 (32.5)	<0.001
Northern	757 (9.8)	418 (54.5)	339 (45.5)	
North western	579 (5.6)	381 (67.2)	198 (32.8)	
Southern	729 (12.9)	518 (69.6)	211 (30.4)	
Western	615 (6.9)	445 (72.5)	170 (27.5)	
Maternal Education				
No education	788 (10.9)	470 (61.4)	318 (38.6)	
Primary	3778 (52.4)	2374 (63.5)	1404 (36.5)	p=0.003
Secondary and Higher	2479 (36.7)	1722 (68.6)	757 (31.4)	
Wealth Index				
Poor	3917 (50.8)	2408 (62.1)	1509 (37.9)	
Middle	1366 (18.2)	914 (67.2)	452 (32.8)	<0.001
Rich	1762 (31.0)	1244 (68.9)	518 (31.1)	
Marital Status				
Ever Married	6487 (92.1)	4212 (65.2)	2275 (34.8)	p=0.653
Never Married	558 (7.9)	354 (64.1)	204 (35.9)	
Total Children Ever Born				
1-3	3713 (53.1)	2425 (65.3)	1288 (34.7)	
4-7	2799 (40.0)	1806 (64.9)	993 (35.1)	p=0.953
8 and Above	533 (6.9)	335 (65.1)	198 (34.9)	
Source of Drinking Water				
Improved	5910 (86.3)	3886 (66.0)	2024 (34.0)	p=0.005
Non-improved	1135 (13.7)	680 (60.0)	455 (40.0)	
Previous Birth Interval (5504)				
≥24 Months	4748 (86.4)	3122 (66.3)	1626 (33.7)	<0.001
< 24 months	756 (13.5)	443 (58.5)	313 (41.5)	

Factors Associated with Stunting Among Children

The factors associated with stunting are shown in **Table 2**. Multiple logistic regression analysis showed that residence, wealth index, maternal education, source of drinking water, previous birth interval were identified to be maternal factors associated with stunting. Furthermore, child age, child, sex, breastfeeding, twin births, size at birth were children factors associated with stunting. After adjusting for stunting in the model, at 95% CI and 0.05 of significance level children in rural areas were 31% less likely to be stunted compared with those from urban (aOR= 0.69 95%CI: 0.56-0.84: p<0.001). Children whose mothers had primary education were 16% more likely to be stunted compared children whose mothers had secondary and higher education (aOR=1.16 95%CI 1.00-1.35; p=0.046).

Children from poor households were 65% (aOR= 1.65 95%CI: 1.32-2.08; p<0.001) high likely to be stunted compared with those from richer households. Children whose source of drinking water was non-improved were 30% (aOR= 1.3095%CI: 1.09-1.5: p=0.003) high likely to stunted than children whose source of drinking water is improved.

Children aged 12 to 23 months of age had 4 times higher odds of being stunted compared with children less than 6 months. Child's sex was significant for predicting stunting. The analysis showed that, child breastfeeding, birth weight, previous birth interval were also significant for predicting stunting (**Table 2**).

Factors Associated with Stunting Among Children

Table II: Univariate and multivariate analysis of Stunting (Height-for-age index)

Explanatory Variables	Crude cOR (95% CI)	P-value	Adjusted aOR (95% CI)	P-value
Maternal Factors				
Maternal Age				
40-49	1		1	
30-39	0.99 (0.81-1.21)	0.906	1.05(0.83-1.33)	0.664
25-29	1.01 (0.82-1.25)	0.905	1.12 (0.86-1.47)	0.384
15-24	1.10 (0.90-1.35)	0.357	1.20 (0.89-1.63)	0.232
Residence				
Urban	1		1	
Rural	1.08 (0.97-1.20)	0.149	0.69 (0.56-0.84)	<0.001
Marital Status				
Ever Married	1		1	
Never Married	1.05 (0.87-1.27)	0.601	1.25 (0.88-1.80)	0.216
Maternal Education				
Secondary and Higher	1		1	
Primary	1.26 (1.13-1.40)	<0.001	1.16 (1.00-1.35)	0.046
No Education	1.38 (1.16-1.63)	<0.001	1.15 (0.93-1.43)	0.191
Wealth Index				
Rich	1		1	
Middle	1.08 (0.93-1.26)	0.29	1.15 (0.94-1.44)	0.174
Poor	1.35 (1.21-1.51)	<0.001	1.65 (1.32-2.08)	<0.001
Total Children Ever Born				
1-3	1		1	
4-7	1.02 (0.92-1.13)	0.732	1.02 (0.87-1.20)	0.783
8 and Above	1.01 (0.83-1.23)	0.931	1.02 (0.77-1.36)	0.895
Source of Drinking Water				

Improved	1		1	
Non-improved	1.29 (1.12-1.49)	<0.001	1.30 (1.09-1.54)	0.003
Previous Birth Interval				
≥24 Months	1		1	
< 24 months	1.40 (1.19-1.64)	<0.001	1.34 (1.13-1.58)	<0.001
Child Factors				
Age in Months				
<6	1		1	
6-11	1.46 (1.13-1.87)	0.003	1.47 (1.09-1.98)	0.011
12-23	3.14 (2.54-3.87)	<0.001	3.76 (2.92-4.84	<0.001
24-59	2.59 (2.13-3.15)	<0.001	2.84 (2.21-3.64)	<0.001
Sex of children				
Male	1		1	
Female	1.37 (1.24-1.52)	<0.001	1.55 (1.37-1.74)	<0.001
Child Breastfeeding				
Yes	1		1	
No	1.27 (1.15-1.40)	<0.001	1.20 (1.04-1.38)	0.015
Twin births				
Singe Birth	1		1	
1st of multiple	3.02 (1.95-4.68)	<0.001	2.65 (1.61-4.36)	<0.001
2nd of multiple	2.42 (1.60-3.67)	<0.001	2.19 (1.36-3.51)	<0.001
Child Size				
Large	1		1	
Average	1.29 (1.14-1.46)	<0.001	1.43 (1.24-1.65)	<0.001
Small	2.23 (1.86-2.67)	<0.001	2.52 (2.01-3.16)	<0.001
Immunisation				
Fully immunised	1		1	
Not Immunised	1.03 (0.91-1.18)	0.6	0.93 (0.72-1.10)	0.380

Discussion

The study intended to identify factors associated with stunting among children aged 0–59 months from the 2018-2019 ZDHS data. The prevalence of stunting among children under five was 34.9% and was more prevalent among male children than female children. This finding is similar to other studies conducted around the world that have also revealed higher prevalence of stunting in boys than in girls [8]. Sex differences could also be attributed to behavioural patterns of communities. For instance in Ethiopia, priority is towards daughters [9]. Prevalence was high in Northern 45.5% followed by Luapula 44.8%.

We found that stunting increases as the age of a child increases; this is similar to what [10] found in their studies. This increase in stunting as age increases attributed to extended periods of inadequate food intake and increased morbidity among children 12–59 months. Further, breastfeeding is consistent in the early life of the child but after 6 months of lactation, breast milk which contains both zinc and vitamin A becomes inadequate for growth. Thus without necessary increase in the nutrient supply to infants by increasing the intake and nutrient concentration of breast milk and of supplementary foods to provide supplements, as the child ages will have nutrients deficits which hampers their growth and good health.

In the past, studies showed that populations that live in rural areas are at a higher risk to nutritional deficits albeit, we found that children in urban areas had a higher risk for stunting than children in rural areas. Our study is congruent with other studies that found similar results [11]. This could be that the risk of stunting in urban is due to declining maternal contact time due consistence engagement in economic activities such as full-time employment that may shorten period of breastfeeding, early cessation of breastfeeding and improper complementary food, which have a largely negative effect on the growth of the children. This entails that most of the urban population might actually be urban poor who live in informal settlements such as slums live in abject poverty, poor water and sanitation, high food insecurity and limited nutritious foods as the case of Lusaka City. Rural populations may have opportunities to grow nutritious rich foods while urban poor are highly dependent on food purchase and diets lack diversity. Child birth size has a direct relationship with stunting. Small or average birth weight children were likely to be stunted compared with children whose birth weight was recorded as large; this is similar to studies done in Pakistan and Ethiopia [10]. This could be linked to mother's health and nutritional status before and during pregnancy which regulate the size of the child during intrauterine period as low birth weight is considered to be an indicator of restricted intrauterine growth.

This study reveals that infants born <24 months after the birth of the previous sibling were more likely to be stunted than those born ≥24 Months afterwards. The resulting poor nutritional status of their mothers, coupled with the increased burden of child care, may result in reduced nutritional status of the infants including stunting. Good children spacing would enable mothers to provide better nutrition, care and attention to their children. The consequences of poor nutrition of a mother and her fetus extend far into later life of the child and possibly into the next generation and this is consistence with other studies [12]. It will be important to do a follow study on this children later in life. We found that, children who were not being breastfed at the time of the survey were more likely to be stunted compared to those who reported being breastfed. These findings accorded with previous studies that showed that children who are not breastfed are more likely to become stunted than children who are breastfed [11]. This could be that breastfeeding promotes child survival, health, brain development. Early initiation of breastfeeding prevents neonatal and infant deaths by reducing the risk of infectious diseases.

Further, breast milk is an important source of both zinc and vitamin A for the infants during infancy. Although Zinc from breast milk is well absorbed however, it becomes inadequate for growth after 6 months of lactation.

Maternal education play a significant role in determining stunting in children. Studies confirm that higher educated mothers understand and are act more responsively to the nutrition of their children, seek disease prevention and treatment, and maintain sanitary living. This could be because of exposure to media; they are likely to have better child and healthcare knowledge of nutrition. This study shows that children whose mothers had primary education were likely to be stunted compared to those whose mothers had secondary education. The same has been confirmed in previous studies and the results imply that maternal education may provide protective effects against all under-nutrition indicators in children [10].

The study indicates that children from richer households were less likely to be stunted compared to those in poorer households. These findings are consistent with the other studies done on stunting [10]. This could be that that richer household are able to afford beyond basic needs such piped water, education, dietary foods, education, employment, and healthcare which considerably impact the health of their children.

Water and sanitation also has a significant impact on child nutritional status as lack of water in households makes basic hygiene somewhat unattainable. In the present study, stunting was significantly associated with source of drinking water. We found that children whose source of drinking water was non-improved were likely to be stunted compared to children whose source of water was improved. This may be attributed to the fact that non-improved water sources may be contaminated and thus may upsurge the risk of infection such as diarrhea. The study findings are consistent with other studies [6].

This study had some limitations. Firstly, limitation of cross-sectional data is their pictorial nature that makes establishing a temporal sequence of events and drawing causal inferences difficult as this pertains to the period and season the survey was undertaken. A few key variables could not be included because of difference in classifications, as data was collected and classified by ZDHS team. For instance, the ZDHS only classifies urban residence as urban even though it includes peri-urban areas thus the definition was not precise. Regardless of the limitations, however, it was possible to indicate the risk factors associated with stunting.

Conclusions

Stunting is a serious public health concern associated with various factors including nutritional, socio-economic, demographic and environmental factors that impact on children's health and wellbeing. These factors often not only influence stunting but also influence nutritional status of a child. Consequently, improvements in maternal education, household wealth, food diet diversity, water and sanitation could improve health status of children. Stunting affects health status and productivity later in adult life. Thus, the consequences of socio-economic inequalities in childhood nutritional status are likely to be recurring. Therefore, with this information on factors associated with stunting, there is need for effective strategies to prevent and treat stunting in Zambia. The health strategies like Community-based Interventions are mostly needed for managing the risk factors of stunting. The multidisciplinary approach that includes both national and international health institutions are certainly needed to be reinforced for lessening the burden of stunting among children under 5 years.

The Zambia government is recommended to keep empowering and encouraging health facilities to provide health education to pregnant and non-pregnant women about how to behave for reducing and adjusting stunting among children. We recommend that additional research should be carried out to explore the biological and psychosocial effects of stunting on the children under five, their families, communities and the country.

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