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FACTORS ASSOCIATED WITH STUNTING AMONG CHILDREN AGED BELOW 60 MONTHS FROM RURAL MALAWI: A MATCHED CASE-CONTROL STUDY

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ABSTRACT

Stunting currently affects 37% (1.1 million) of Malawian children and causing unfavorable impact for both children and their households. Identifying risk factors to stunting would go a long way in developing appropriate interventions. The objective of this study was to identify the risk factors of stunting among children aged below 60 months from Balaka, Dedza and Mzimba districts in Malawi. A matched cross-sectional case-control study was conducted among 913 (446 controls; 467 cases) children aged below 60 months from three regions of Malawi. Household demographic, anthropometric measurements, dietary intake, food security, and morbidity information were collected. Case-Control Stepwise multiple logistic regression models are used to determine risk factors of stunting. The following were identified as risk factors for stunting including; age of child (AOR= 6.3; 95% CI: 2.9, 8.9), polygamy (AOR= 8.9; 95%, CI: 3.3, 13.03), maternal education (AOR= 9.9; 95%, CI: 2.8, 20.1), access to markets (AOR= 1.3; 95%, CI: 0.2, 2.4), childhood infections (AOR= 2.11; 95%, CI: 1.4, 4.2) and presence of oedema (AOR= 2.5; 95%, CI: 1.3, 4.1). Also, lack of food any month (AOR= 1.31; 95%, CI: 1.01, 4.9), purchasing food on credit (AOR= 1.48; 95%, CI: 1.4, 1.7), begging for food (AOR= 1.55; 95%, CI: 1.2, 2.1), mothers or caregivers consuming less than 5 food groups (MDD-W) (AOR = 4.83; 95% CI: 1.9, 16.4), exclusive breastfeeding (AOR= 5.45; 95%, CI: 4.33, 7.61) children weaned on plain water (AOR= 1.6; 95%, CI: 1.6, 2.41), powdered milk (AOR= 0.63; 95%, CI: 0.4, 1.32), juices (AOR= 0.44; 95%, CI: 0.12, 0.96) and children fed on sugary food (AOR= 0.66; 95%, CI: 0.4, 0.99) were significantly related to stunting. Stunting is associated with increasing age of children, boys, polygamous households, lack of education by mothers or caregivers, inaccessible markets, childhood infections and presence of oedema, food insecurity, breastfeeding and complementary feeding among children and dietary diversity of mothers or caregivers. These results suggest that interventions against childhood stunting should be designed according to the factors that significantly affect stunting.

Key words: child growth, Malawi, stunting and complementary feeding, Regression, Food Security and Health

INTRODUCTION

Childhood stunting is one of the most serious health problems faced by most sub-Saharan African countries, including Malawi. Globally, Africa is the only region, where the number of stunted children has risen from 50.3 million in 2000 to 58.8 million in 2018 [1]. In Malawi, stunting currently affects 37% (1.1 million) of children [2], making stunting one of the most serious health and welfare challenges that need urgent and continued attention [3]. Over the last few decades, creation of good governance structures and advocacy for multi-prong approach to solving nutrition challenges in Malawi has resulted in substantial decline in undernutrition [3]. Despite this, stunting remains at an unacceptably high level, which seriously disrupts public health and socio-economic fabric for the country [2,3]. The cost of hunger study commissioned by the United Nations Economic Commission for Africa (ECA), revealed that a Malawian person who was stunted as a child, has average schooling achievement of 1.5 years lower than that of a normal person. Further the study revealed that 18% school repetitions among Malawian children, are associated with stunting [3]. In addition, the ECA report attributes 23% of children mortality to undernutrition and 10.7% workforce loss in Malawi to child mortality caused by undernutrition. Despite the problem of stunting being well documented in Malawi, there are inconsistencies across several studies regarding the determinant factors behind stunting in childhood. Espo *et al.* [4], investigated predictors of stunting and linear growth among one year old children in rural Malawi, while Maleta *et al.* [5], conducted a longitudinal study following up a cohort of 767 children from birth to 36 months to characterize the determinants of malnutrition. Stewart *et al.* [6], documented effect of consuming eggs among children on growth outcomes and Prado *et al.* [7], performed path analysis among children aged 6-9 months under who participated in feeding trials lipid based nutrient supplements. As result these studies [4, 5, 6, 7] conducted among few and isolated pilot villages in Malawi, are incomparable because they focused on different age groups and the study objectives are not similar have documented a number of risk factors for stunting. Therefore, having a scientifically sound study to identify potential risk factors of stunting among a wide age bracket of Malawian children aged below 60 months, would be important in influencing policy in designing comprehensive interventions to address stunting among children in Malawi and beyond. Therefore, this study was worth conducting to investigate context specific determinants of malnutrition in Balaka, Dedza and Mzimba districts. The study was conceptualized through adaptation of the United Nations Children's Fund (UNICEF) conceptual framework for causes of malnutrition and the Feed the Future conceptual pathways between agriculture and nutrition [1]. The study investigated major socio-economic, demographic, health and dietary intake,

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food security, risk factors for stunting among infants aged 0–60 months from the central region of Malawi, including districts of Balaka, Dedza and Mzimba. The research results obtained would be helpful to overcome the problems of stunting and food insecurity and their consequences, enabling healthcare providers in designing and implementing appropriate interventions to improve the growth of children in Malawi. Results will further enable the government and non-governmental agencies to formulate evidence-based policies, strategies and interventions for the wellbeing of the population.

METHODS AND MATERIALS

Study sites and collaborators

The study was conducted in three districts of Mzimba, Dedza and Balaka (Figure 1), in 2018 using a cohort nested to the 2010 Demographic and Health Survey (DHS) report [2]. The most recent stunting data of the 2010 DHS stunting were used to compute the sample size for the study population. The study was conducted in collaboration with the National Statistical Office (NSO) and the District Nutrition Coordinating Committees (DNCCs) of the three districts. In this cohort, we recruited children aged below 60 months and their caregivers, including non-biological mothers, from households surrounding the selected villages, commonly referred to as Traditional Authorities (TA) in Malawi.

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Figure 1: Map of Malawi indicating the three study districts sourced from the 2015/16 MDHS report

Study design and sampling procedure

A purposive sampling technique was deployed to select the districts and the TAs by engaging the district stakeholders to identify the TAs that can be accessed by the road network in each study sites. The TAs were selected in consideration of high malnutrition levels, availability of children and their mothers or caregivers and where there are few government and stakeholders work. Secondly, in consultation with the NSO, a total of 31 standard enumeration areas (SEAs) were randomly selected in each TA. To give equal chances of participating in the study, all households in the selected SEAs were listed to formulate a sampling frame. Care group promoters and cluster leaders in each of the study sites were recruited, and their primary role was to list all households in the SEAs and identify households with children aged below 60 months. A list of eligible households for screening, with at least one child below 60 months old was extracted and then 40 households were randomly selected from each SEA. A community based matched case-control design, in a ratio of 1:1, was applied based on age, sex and location. Case-control

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studies are preferred because they are quick, inexpensive, and easy to conduct and the most appropriate to investigate causes of health outcomes [4].

The village nutrition coordinating committee (VNCC) members and area nutrition coordination committee (ANCC) members provided the first level of the supervision, at the village and TAs levels respectively, for the entire process of household selection. The overall supervision was provided by the NSO, district nutrition coordinating committee (DNCC) and the project team members. The household listing team members received a two-day training facilitated by NSO, DNCCs and project team members, during which they were oriented on data collection, filling of the forms and reading the map.

Sample size calculation
The formula for the total sample size required for comparing two independent event (stunted and not stunted) rates was computed according to Kirkwood and Sterne [8].

$\underline{\{u \sqrt{[\pi_0(1-\pi_0)+\pi_1(1-\pi_1)]} + v \sqrt{[2\pi(1-\pi)]}\}^2}$

$(\pi_1 - \pi_0)^2$

$\sqrt{}$ = square root, π_0 Proportion of controls exposed, π_1 Proportion of cases exposed, calculated from

$\pi_1 = \underline{\pi_0 OR}$

$1 + \pi_0 (OR-1)$

π (mean) = $\underline{\pi_0 + \pi_1}$

OR = odds ratio, u One-sided percentage point of the normal distribution corresponding to 100%- 80% - power u = 0.84, v Percentage point of the normal distribution corresponding to the (two-sided) significance level =5% v = 1.96

Assuming current stunting is 40% per district, power 80%, Πo is 0.6, π1 is 0.75, π (mean) is 0.675, control to case ratio is 1:1, odds ratio 2.0, alpha 0.05 and beta 0.2, the sample size per district is 304. This sample size achieves 50 percent (n = 152) in the case group and 50 percent (n = 152) in the control group per district. Therefore, sample size for the three districts was 304*3=912 children

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Recruitment and training of enumerators

A total of 16 enumerators were recruited from members of the District Nutrition Coordinating Committee (DNCC) in the selected districts and drawn to a central place in Lilongwe. To be eligible the DNCC member had either health or nutrition background and had prior hands-on experience in taking anthropometric measurements. A six-day training in anthropometric assessment following formal standardisation against an "a gold standard" experienced anthropometrics and questionnaire administration were conducted. The training involved theory and practice sessions in classroom setting and later pre testing in the field with care givers and their children aged below 60 months in communities around Lilongwe district. Two field practice standardisation tests were done in two different communities to make sure that enumerators became more confident with taking anthropometric measurements.

Screening children aged below 60 months

The reference children aged below 60 months from the selected households were screened. Screening involved taking anthropometric measurements of children; weight, height/length, mid upper arm circumference (MUAC), bilateral pitting oedema and information on age and sex for the child. Child age was confirmed using his/her birth certificate, or by the response from the mother or caregiver if the birth certificate was not available. Anthropometric measurement data were obtained from the child cohort dataset. The height was measured by a length scale (Seca GmbH & Co.Kg, Germany). Accuracy of the height of the child was recorded with a range of 0.10 cm with the help of a rod out of the anthropometer, with the head held in the Frankfort horizontal plane. Height was measured for children above two years of age, while length for children below two years using a length/height board. Weight was measured using pants for baby weighing scale (G.S.T. Corporation, India) and portable electronic scale (Guangzhou Weiheng Electronics Co., Ltd, China) for babies; and KRUPS Baby Cum Child Weighing Scale (Doctor Beci Ram & Sons [MFG.], India) for children who could stand. Accuracy of the weight of the children was taken to 0.1 kg, using minimum clothing and with bare feet, and the device was calibrated frequently. Chronic malnutrition (stunting) of children was defined as z-score below 2 standard deviations (SD) from the mean for length or height for age according to the WHO Child Growth Standards [9]. For this study, those who had a z-score above −2 SD were defined as children who did not have stunting. Screening started in Dedza, then Balaka and finished in Mzimba South and a total of 3685 children were screened (Table 1). The idea was to improve validity and reliability of data since the team kept on

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improving their skills, precision, and confidence as they moved from one district to another.

Selection of cases and controls

Cases and controls were selected from all screened households with children aged below 60 months. For every case selected one control was selected until the required sample size was achieved. In the case of households with multiple children aged below 60 months, these were counted as one household and in case of households with multiple children where one child was stunted and another not, such household was classified as case household.

Inclusion and exclusion criteria of households

Children were included or excluded in the study, based on the stunting data of children collected during the screening. A child was included if the mother or caregiver was willing to participate, had a child below 60 months and resided in the selected TA. A child was excluded when his or her mother or caregiver was unable to respond to the questions due to hearing disability; those who were severely sick, those whose birth date were not appropriate or unclear. A list of potential households enrolled in the study was generated and shared with the statistician and the project staff and enumerators. An additional list without the household and child ID was generated and shared with the frontline workers, promoters and cluster leaders to assist with the random location of the households within the TAs.

Data collection and quality assurance

Data were captured by tablets using Open Data Kid (ODK) software, which allowed collection of data offline in remote areas with ease. The study focused on interviewing women because in rural African settings women are responsible for food collection and preparation and are custodians of knowledge on household food preparation, that is passed on from generation to generation [10]. The interview required approximately 20 minutes to complete. The structured questionnaire consisted of the following independent variables: demographic characteristics, agricultural, time spent visiting health centers, productivity, access to markets and infrastructure, breast feeding, complementary feeding, food insecurity and coping strategies, child health and growth curve, mother/caregiver's dietary diversity and mother consumption of five or more food groups known as minimum dietary diversity for women (MDD-W).

Household demographics, child health care and growth, access to health centers, agricultural production and markets characteristics were assessed using a structured questionnaire. Dietary assessment for children and their mothers were assessed using two 24 h recalls with each recall conducted in the space of one week. The means of the two recalls were used for analysis. The two 24 h recalls allowed minimizing of intra-individual intake variation [10]. The 24 h recall was validated based on previous studies conducted in Malawi [11, 12]. A list was recorded of meals, dishes, food items and beverages consumed during the last 24 h. Respondents were asked for a full description of ingredients in mixed dishes. Respondents were also prompted for specific foods such as snacks and drinks. Dietary diversity scores were obtained from the eleven food groups specified in the [13] guidelines for measuring household and individual dietary intake. The food groups were: (i) cereals and wheat products; (ii) roots and tubers; (iii) legumes and lentils; (iv) nuts; (v) dairy and fats; (vi) meat and game; (vii) poultry; (viii) fruits; (ix) fish and seafood; (x) vegetables; and (xi) non-alcoholic beverages. The food items consumed were allocated among the eleven food groups and the dietary diversity score (DDS) was calculated by summing the number of unique food groups consumed by each child.

The Household Food Insecurity Access Scale (HFIAS) and coping mechanisms were assessed following the procedure proposed by Coates *et al.* [14]. A set of nine standard questions was posed to women, who responded on behalf of other household members. The HFIAS score is a continuous indicator ranging from 0 (food secure) to 27 (maximum food insecurity) [14], with the score categorized into four levels of household food insecurity: food secure (score =0), mildly (score=1–13), moderately (score =14–16) or severely food insecure (score =17–27).

Variables selected to include in analysis

Variables were selected based on determinants including; inherent (age and sex), proximal, intermediate (days of exclusive breastfeeding, household food insecurity, mother's dietary intake and complementary feeding) and distal (education, literacy level, household income and access to markets) [15, 16], and availability of data from the present study. The repeated longitudinal data, the stunting outcome was considered and defined at 0-5, 6-11, 12-23, 24-35, 36-47, and 48-59 months of age. Marital status was considered married-monogamous, married-polygamous and single, widowed or divorced. Maternal or guardian education has been categorized into 4 groups as no schooling, primary, secondary and above secondary schooling. The rest of factors were categorized into a no (not in agreement) or yes (affirmation) (Table 2).

Data analysis

Data were checked for completeness, edited, coded and entered into MS Excel and exported to XLSTAT (version 2012.10.7.01 Addinsoft, Paris France) statistical

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software for analysis. After cleaning the data for inconsistencies and missing values, descriptive statistics were done. The mean values and standard deviation (SD) were computed for continuous variables, while proportions were computed for the categorical variables. For all anthropometric variables, it was observed that the p-value was statistically significant ($p < 0.05$). Analysis of variance (ANOVA) using the Scheffé post-hoc test was applied to evaluate the mean differences by age in the anthropometric variables.

A logistic binary regression model was performed to establish the effect of the dependent variables on the outcome, stunting in children aged below 60 months. Households with multiple stunted children aged below 60 months, they were counted as one household and in scenario of households with multiple children where one child was stunted and another not, such household were classified as case households. The outcome was modelled as a function of 6 vector clusters of factors: household demographic factors, access to markets, food insecurity and coping strategies, child complementary feeding, childhood infections and presence of oedema and mother dietary diversity. The model produced estimated odds ratios (OR) and 95% confidence intervals (CIs) which were used to evaluate the possible differences and the associated risk factors among children with height-for-age z-scores less than -2 SD (HAZ < -2 SD) and normal height-for-age z-scores (HAZ > -2 SD).

Under the model, stunting in a child below 60 months is denoted as S, and the vector of factors as X, which ranges from X_1, …, Xn . S is a binary outcome, a household with or with no stunted child and is expressed as log(p/1-p). If we add the error term (e_{ijk}), it is possible to identify drivers of stunting among children aged below 60 months by specifying Logit model as follows:

$$s - b0 + b1 \times 1 + b2 \times 2 + \cdots ... + bk \times k + c ....1$$

Where S equals log(p/1-p) and p is the probability that S (outcome variable) equals to 1; b_0 ……b_k are estimated parameters, $x_{1.....}x_k$ are explanatory variables and e is the random error term.

The presence of a stunted child in the household is used to define the household as a case (where S=1 when a stunted child is present) or control (where S=0 when there is no stunted child in the household). The binary logistic regression analysis produced odds ratio scores which were compared with the reference category in the analysis of the univariate independent model. Variables with p-values less than 0.05 in the bivariate analysis procedure, were included in a backward stepwise multiple logistic regression. The multiple logistic regression analysis in the conditional model was performed to determine the most effective predictive variables from the variables considered in the binary logistic regression analysis. Multi-collinearity between independent variables were performed from correlation matrix and variance inflation factor (VIF) values, with VIF < 2.5 used as a cut-off point. The odds ratios with 95% CIs were calculated in order to assess the adjusted risk of independent variables, and those with $p < 0.05$ were retained in the final model [17, 18].

Ethical considerations

Ethical approval was provided by the ethics Committee of the National Health Sciences Research (NHSR), with the formal ethical approval No 17/03/1745 provided to the research team. Also, the National Statistics Office (NSO) in Zomba provided a letter of support to this study. At district level, the District Commissioners (DC) and the District Health Officers (DHO) for Mzimba South, Dedza and Balaka districts provided letters of support. Letters of support from community-based collaborating partners at the district level were granted by United Purpose society for Dedza and Balaka districts and Mzuzu CADECOM group for Mzimba South district. Under each district, at the TA, the Area Development Committees (ADC), representing development committees at the TA level, provided clearance of the study. Specifically, the approval was obtained from Kachenga, Kaphuka and Khosolo ADCs in Balaka, Dedza, and Mzimba South districts respectively. At all the stages of survey activities, informed and written consent was obtained from the study participants. Specifically, the head of household, reference mothers and caregivers also gave consent on behalf of their children. All the participants involved in the study were informed about the research objectives and the confidentiality of the data. The participation of the subjects was completely voluntary in nature. In the cases where the respondents were illiterate, a literate person from the community read out the consent form and explained it to the head of the family in local language. Then we obtained the thumb print of the respondent. In those cases, the person who read the consent form also signed as a witness. The research procedures were consistent with the Declaration of Helsinki [19].

RESULTS AND DISCUSSION

Risk factors for stunting among children aged below 60 months

Out of 3738 children screened to identify cases and controls, a total of 913 children aged below 60 months with their mothers or caregivers were included in this study (467 cases and 466 controls) (Table 3). In the multivariate logistic regression analysis, nine factors remained significantly associated with stunting (p ≤0.05) (Table 4). To avoid the risk of overfitting, only the most significant variables observed in the bivariate logistic regression analysis were selected to fit in the multivariate model. The findings showed that the overall prevalence of stunting in the three districts of Balaka located in Southern region, Dedza in Central and Mzimba district in Northern region of Malawi, was observed to be 30.2% among 3,738 children who were screened to identify cases and control groups (Table 3). Using the WHO reference, prevalence classification [20], levels of stunting are considered a public health concern when there above 20%. The rate of 30.2% stunting is much higher than the 20% critical public health thresholds. Then again, the prevalence of 30.2% is below the national level of 37% reported by the 2015 Demographic Health Survey (DHS) for this age group, suggesting a possible decline in stunting in Malawi. The decline may be attributed to the economic and structural policy changes in Malawi [21], with more resources being allocated to key sectors of the economy including agriculture, education and health, thus having impact on nutrition outcomes generally. The World Bank Group Malawi situation report [22] reveals that by end of 2019 Malawi's economy grew by 4.4%, a marked increase from 3.5% in 2018. The growth was majorly supported by a reverberation in agriculture. A recent study by Ryckman *et al.* [23], also reported a decline in stunting among children aged below 60 months, in 21 Sub Saharan Africa Feed the Future focal countries including Malawi.

The study findings depicted sex of Malawian children to be an important predictor for stunting. The prevalence of stunting is higher in boys than girls. Inferring to distribution of stunting by sex, 34% of the cases were boys with majority (33.2%) residing in Mzimba-South district (Table 3). Boys (AOR= 1.41; 95%, CI: 2.2, 1.7) were more likely to develop stunting compared to girls (Table 4). These findings are consistent with other studies reporting similar trends from sub-Saharan Africa [24, 25, 26]. On contrary, previous studies in Kenya [27, 28], Ethiopia [29] and Tanzania [30] reported mixed findings on the effects of sex, with some suggesting that boys are more affected by stunting compared to girls, while others reported otherwise. In the present study, the findings are consistent with the national statistics reported in Malawi DHS [2]. Condo *et al.* [7] postulates that boys are expected to grow at a slightly more rapid rate compared to girls and their growth is perhaps more easily affected by nutritional deficiencies or infections. Then again, Wamani *et al.* [24] using meta-analyzed DHS data of 16 sub-Saharan African countries, revealed that preferences in feeding practices for girls and boys at family level could explain why boys were more exposed to stunting than girls. Cultural beliefs in Africa, attach economic importance to girls than boys, a scenario which can explain the high prevalence of stunting among boys [25]. Girls are well fed and

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given more care among majority of low income African settings, first because of the value attached to their contribution in terms of free labor to agriculture and secondly due to the fact that they are seen as an investment for future earnings in form of price for dowry [24]. Considering that over 84% of Malawi population depends on agriculture and that the majority of the population is socio-economically constrained, with an estimated 51% living below the poverty line of $1.25 per day while 25% are living in extreme poverty defined as the inability to satisfy food needs [31], this notion may as well explain why boys are more malnourished. Additionally, surveillance studies reveal that boys are more biologically vulnerable to morbidity [32, 33], and, in a setting such as Malawi where incidences of morbidity are high, this may exert considerable effects on boys.

In the present study stunting was found to be directly related with the rise in age of the child. Stunting was evident at 0-5 months (2.6%) and exponentially increases with age between 6-47 months, with a small decrease at 48-59 months (Table 3). When they were grouped by age intervals, a significantly ($p=0.001$) higher percentage of stunting was observed among those aged 24-35 months (39.2%) and those aged 36-47 months (35.7%). Furthermore, multivariate analysis revealed that children who were aged 24-35 months (adjusted odds ratio (AOR= 6.3; 95% CI: 2.9, 8.9) had the highest odds (6 times likelihood) to develop stunting than those aged 12-23 moths (AOR= 3.4; 95%, CI: 1.4, 5.6) or those aged 36-47 months (AOR= 4.2; 95%, CI: 2.9, 6.8) (Table 4). Children aged 6-11 months were the least (AOR= 1.04; 95%, CI: 0.3, 2.1), likely to be stunted. About 2.6% children in cases and 8.5% among the controls, below aged below 5 months who are supposed to be exclusively breastfed, were stunted. These findings are in agreement with findings elsewhere that indicated that children below 5 years were stunted, and have been reported in Mozambique [25], Ethiopia [29], Nigeria [34] and Kenya [35]. This observation could be due to the inappropriate and late introduction of low nutritional quality complimentary foods to children [36]. For example, findings in the present study, revealed that Malawian children who were weaned on either plain water, juices or sugary foods were significantly ($p\leq0.05$) likely to be stunted. A large proportion of mothers or guardians in rural areas are ignorant or lack adequate nutrition knowledge, to enable them prepare a balanced meal, which can optimally meet the nutritional requirements of the children, as the children grow [37]. In addition, the presence of stunting in 0-5 months old infants in the present study, can be related to lower breastfeeding rates observed, where 68.7% of mothers with stunted children did not practice exclusive breastfeeding. This may imply that exclusive and continuous breastfeeding of children has protective outcomes in children as defined by the WHO [38].

Polygamous households in Malawi, were associated with higher odds (AOR= 8.9; 95%, CI: 3.3, 13.03) of having stunted children than in monogamous marriage households (Table 4). In the present study, polygamous marriages were strongly associated with stunted children. Polygamous households in the present study have larger average number of household members (more than five members). This finding is in line with a report that found a significant relationship between bigger household sizes and childhood undernutrition in Eastern Uganda communities [39], Ghanaian children [40] and children raised in the central region of Mozambique [24]. With large number of household members, there is increased competition for household resources including food and access to health and care [41]. In rural poor Malawi settings such as Dedza, Mzimba and Balaka, polygamy is therefore, a major socio economic constraint. Basic household needs such as access to safe water, access to toilets, health services, and practices such as hand washing using soap, and other sanitation practices can be scares resources for poor polygamous households, thus exacerbating malnutrition. A consensus regarding the importance of subsidized or free public education for all children, free health care and family planning for parents is also required because mothers or guardians play an important role in the development of healthy infants and young children.

The childhood stunting in the present study was also found to be inversely associated with the mother or guardian's level of education. Children living with mothers or caregivers with no education (AOR= 9.9; 95%, CI: 2.8, 20.1) were about 10 folds likely to develop stunting than children with mothers who had formal education (Table 4). This observation is in agreement with a number of studies conducted elsewhere in several sub-Saharan African countries [27, 34, 39, 42]. The present findings demonstrate the importance of education to girls as an alternate strategy to address stunting, adult poverty and to push better feeding practices for young children. Educating girls or women represents an opportunity of gainful employment in adulthood with a higher paying job, which may result in an improved access to the markets and better household feeding practices [43, 44]. Additionally, García Cruz *et al.* [25], reported that educated mothers poses positive attitudes, and better skills, knowledge and understanding and improved practices of child and healthcare, health seeking behaviors, access to medical care and lower fertility rates. Certainly, in the present study, a significant proportion of children whose mothers or guardians had a higher education may have followed a diet that met the recommended dietary diversity, in comparison with their counterparts whose mothers had no any form of education.

Access to markets which was a measure of, type of road, distance and time spent, were observed to be a considerable risk factor for stunting. Households that cited bad road conditions, longer distance and time spent to get to the market, were 1.3 times more likely (AOR= 1.3; 95%, CI: 0.2, 2.4) to have a stunted child (Table 4). The result appears counterintuitive; however, these are likely to be households that relate to the markets frequently or have the need to access the markets for their food requirements. Households with a stunted child appear to relate less with the market. Another factor associated with access to food markets is the importance of food product diversity that households can access. Lack of accessibility of a diversity of foods in the markets or gardens by mothers (MDD-W) in the present study, was associated with higher chances of having a stunted child by about 4.8 odds. These findings are in agreement with earlier findings from Malawi reported by Koppmair *et al.* [45], who revealed that distance to the districts market and longer walking times however, is statistically significant associated with lower dietary diversity and the nutritional outcome of stunting.

Child health indicators such as presence of oedema and infections were found to be significantly associated with childhood stunting. Children who had oedema (AOR= 2.5; 95%, CI: 1.3, 4.1), and those who had suffered from infections (AOR= 1.45; 95%, CI: 1.1, 2.03), were likely to be stunted (Table 4). Similar findings have been reported in Mekelle city of Ethiopia, where children who are hospitalized due to diarrhea were 5 times more likely to be stunted [46]. Children aged below 60 months, have poor nutrition because their age group is highly associated with increased exposure to infections, due to being introduced to taking other fluids (non-breast milk) and/or solids as well as ingestion of contaminated materials as they explore their environment. In the present study children were introduced to taking plain water and sugar beverages as an alternate to breast milk, exposing children to infections. Most of these foods are low in protein and essential nutrients required for growth, but high in energy and carbohydrates. As consequence, infected children have low appetite and reduced nutrient absorption hence exacerbating nutrient losses and affecting metabolic requirements [47]. García Cruz *et al.* [25] observed that among Mozambican children, there is a reciprocal relationship between infections and undernutrition and undernutrition predisposing children to infections. Undernourished children such as the ones observed with oedema in the present study, can have more severe disease episodes and a sick child is more prone to being undernourished.

Regarding food insecurity, households that lacked food any month during the year (AOR= 1.31; 95%, CI: 1.01, 4.9), those that purchased food on credit (AOR= 1.48; 95%, CI: 1.4, 1.7) and households that begged for food, had higher odds (AOR=

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1.55; 95%, CI: 1.2, 2.1) of having stunted children compared to households that did not face any of the three food insecurity scenarios (Table 4). These may imply that stunting is highly affecting children whose mothers or caregivers who marginally feed their children on daily basis. The complex relationship between food insecurity, lack of child care and stunting has previously been documented among children residing in highlands of Ecuador [48] and preschool going children in Turkey [49]. Furthermore, some studies in Latin America and sub-Saharan Africa have associated food insecurity with stunting due to presence of many children in the family [43, 46 and 48]. In addition, caregivers or mothers with many children, may not be able to pay adequate attention to children aged below 5 years old due to the need to attend to their own responsibilities. Social support such as having assistants commonly referred to as maids in Malawi, to help mothers and caregivers, is required for adequate child growth [48].

The likelihood of stunting was about 4.5 times (AOR= 5.45; 95%, CI: 4.33, 7.61) higher among children who were not breast fed compared with children who were exclusively breast fed for six months (Table 4). This finding is comparable with findings registered among children aged below 60 months residing in Tanzania [42] and Brazil [43] and in food surplus region of Haramaya district, Eastern Ethiopia [29]. For example, Yisak *et al.* [29] reported 2 folds increment of stunted children in Ethiopia, when their mothers reduced breastfeeding after starting complementary feeding. Children who are breast fed beyond 6 months, have lower chances of being susceptible to stunting [33], further supporting findings in the present study that revealed that breastfeeding has a positive association with stunting.

It was further observed in the present study, that inappropriate introduction of unhealthy complementary food such as plain water and sugary foods to a child substantially affect his/her stunting status. For example, Malawian children fed on plain water (AOR= 1.6; 95%, CI: 1.6, 2.41), those fed on powdered milk (AOR= 0.63; 95%, CI: 0.4, 1.32), those served juices (AOR= 0.44; 95%, CI: 0.12, 0.96) and those fed on sugary food (AOR= 0.66; 95%, CI: 0.4, 0.99), their likelihoods of being stunted were significantly high (Table 4). This scenario may be explained by children or infants having under developed digestive and immune systems.

A strong association between stunting among children with their mothers or caregivers dietary diversity was observed in this study. Stunted children in Malawi, were more likely to be looked after women or guardians who do not consume milk (AOR= 3.1; 95%, CI: 2.1, 4.9) and mothers who consume sugary foods (AOR= 0.48; 95%, CI: 0.25, 0.7) (Table 4). Mothers' dietary practices are long time behavioral practices, which in turn have significant effect on the child's dietary practices and their nutrition outcomes such as stunting [35, 39]. Then again, this study revealed that children whose mothers that consumed 5 or less food groups (MDD-W), (AOR = 4.83; 95% CI: 1.9, 16.4) were significantly more prone to being stunted (Table 4). About 785 (87%) women in this study did not meet their minimum (5 or more) food groups requirements (the minimum dietary diversity for women (MDD-W), while only 120 women consumed 5 or more food groups. This observation points to inadequacies in both quality and quantity of mother's feeding in Malawi. In Mozambique, [25], Ethiopia [29] and Tanzania [30], similar findings have been documented among mothers who are undernourished, being more likely to have stunted children. The MDD-W indicator used in the present study, is a validated proxy, widely being used to assess the probability of micronutrient adequacy of diets. Marriot *et al.* [38], reported an increasing likelihood of stunting among children aged between 6 and 23 months, whose mothers' dietary diversities were not meeting the minimum scores in several African countries. Maternal nutrition status has previously been reported to affect the composition of breast milk growth micronutrients including; vitamin A, iodine, riboflavin, thiamine, and others [38]. As a consequence, maternal deficiency is directly related with infant deficiency, especially for vitamin A, whose stores are low at birth.

The limitations of this study include; firstly, the odds ratios interpretation should be done with caution because they were higher than one, secondly the design of cross-sectional deployed in this study, makes it hard to scrutinize causal and possible relationships and thirdly bias due to poor memory, cannot be ruled out, for example, administering the 24 hours recalls. These are potential confounders and can lead to an erroneous interpretation of results in the present study.

CONCLUSION, AND RECOMMENDATIONS FOR DEVELOPMENT

About a third of the children aged below 60 months in the study sites were found to suffer from stunting. Stunting was strongly associated with increasing age of children, boys, polygamous households, lack of education by mothers or caregivers, inaccessible markets, childhood infections and presence of oedema, food insecurity, breastfeeding and complementary feeding among children and dietary diversity of mothers or caregivers. These results suggest that nutritional interventions against childhood stunting, should be designed considering the identified eleven risk factors.

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Table1: Listed households, the number of children screened at a response rate of 81%in Malawi

District	Traditional Authority (TA)	Household Listed	Household with children below 60 months*	Total No of children below 60 months	No of Children Selected for Screening	No. of children screened	Response Rate (%)
Balaka	Kachenga	7,045	4,020	6,044	1490	1200	80.5
Dedza	Kaphuka	8,966	4,394	5,355	1490	1215	81.5
Mzimba (south)	Khosolo	7,768	4,345	5,494	1575	1270	80.6
	Total	23,779	12,759	16,893	4555	3685	80.9

Table 2: Distribution of demographic characteristics by stunted and non-stunted status children of mothers and children in Malawi (N = 913)

Characteristics	Study arm	
	Controls (N=446)	Cases (N=467)
	N (%)	N (%)
Sex of household head		
Female	79 (17.7)	93 (19.9)
Male	369 (82.7)	374 (80.1)
Marital status		
Married- monogamous	346 (77.6)	354 (75.8)
Married-polygamous	50 (11.2)	54 (11.6)
Widow or widower, divorced, single	34 (7.6)	77 (16.5)
Highest grade of education completed by HH		
No school	30 (6.7)	34 (7.3)
Primary	304 (68.2)	319 (68.3)
Secondary and above	99 (22.2)	104 (22.3)
Above secondary	13 (2.9)	4 (0.9)
Literacy level		
Cannot read and write	26 (5.8)	33 (7.1)
Can sign (write) only	2 (0.4)	0 (0)
Can read only	2 (0.4)	1 (0.2)
Main material for the roofing of the main dwelling		
Grass thatched roof	325 (72.9)	381 (81.6)
Iron sheet roof	123 (27.6)	84 (18)
Clay tiles	0 (0)	1 (0.2)
Others	0 (0)	1 (0.2)

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Material for the floor of the main dwelling		
Earth/ Mud	401 (90)	434 (92.9)
Cement	47 (10.5)	33 (7.1)
Main material for the walls of the main dwelling		
Mud wall	155 (34.8)	209 (44.8)
Sun dried brick	96 (21.5)	88 (18.8)
Sun dried and burnt bricks	185 (41.5)	160 (34.7)
Concrete block	4 (0.9)	5 (1.1)
Tree trunk with mud	2 (0.4)	6 (1.3)
Wood/ timber	2 (0.4)	0
Grass	3 (0.7)	1 (0.2)
unburnt bricks	1 (0.2)	0
Do you own this house or do you rent		
Rent	41 (9.2)	25 (5.4)
Own	385 (86.3)	419 (89.7)
Relative's house	22 (4.9)	30 (6.4)
Study arm	N	Mean
Age of household head		
Controls	448	34.2±0.47
Cases	467	34.2±0.49
Total	915	34.2±0.34
Household size		
Controls	448	5.0±0.09
Cases	467	5.1±0.09
Total	915	5.1±0.06

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Table 3: Prevalence of stunting in children aged below 60 months in the study districts, Malawi

Characteristics	Height for age-below -2SD (Stunting)		
	Stunted	Not stunted	Total
	No (%)	No (%)	No
Age in months			
0 – 5	28 (11.3)	220 (88.7)	248
6 – 11	53 (13.6)	337 (86.4)	390
12 -23	226 (28.0)	581 (72.0)	807
24 – 35	331 (39.2)	514 (60.8)	845
36 – 47	289 (35.7)	521 (64.3)	810
48 -59	203 (31.9)	434 (68.1)	637
Gender of child			
Boys	618 (33.6)	1224 (66.4)	1842
Girls	512 (27.0)	1383 (73.0)	1895
District/Traditional Authority			
Balaka – Kachenga	309 (25.4)	907 (74.6)	1216
Dedza – Kaphuka	393 (32.1)	834 (67.9)	1227
Mzimba South – Khosolo	428 (33.1)	867 (66.9)	1295
Total	1130 (30.2)	2608 (69.8)	3738

Table 4: Relative Risk (OR) (95% CI) for exposed and unexposed stunted children aged below 60 months, in Malawi

Age in months	Controls (N=446) (%)	Cases (N=467) (%)	Crude OR (95% CI)	Adjusted OR (95% CI)	P-value
0 – 5	38 (8.5)	12 (2.6)			
6 – 11	58 (13)	22 (4.7)	1.19 [0.73, 1.94]	1.04 [0.29, 2.08]	0.4937
12 -23	99 (22.2)	93 (19.9)	3.04 [1.98, 4.67]	3.41 [1.41, 5.61]	<0.001
24 – 35	88 (19.7)	137 (29.3)	5.05 [3.29, 7.73]	6.31 [2.89, 8.92]	<0.001
36 – 47	89 (20.0)	119 (25.5)	4.41 [2.85, 6.83]	4.20 [2.45, 654]	<0.001
48 -59	74 (16.6)	84 (18.0)	3.85 [2.48, 5.98]	3.02 [2.02, 4.87]	<0.001
Gender of child					
Boys	209 (46.9)	255 (54.6)	1.37 [1.19, 1.58]	1.41 [1.21, 1.73]	<0.001
Girls	236 (52.9)	211 (45.2)			
Marital status					
Married- monogamous	346 (77.6)	354 (75.8)	2.11 [3.21, 18.09]	2.09 [1.08, 1.21]	<0.001
Married-polygamous	50 (11.2)	54 (11.6)	7.01 [1.08, 13.11]	8.87 [3.23, 13.03]	<0.001

Widow or widower, divorced, single	34 (7.6)	77 (16.5) (ref)			
Highest grade of education completed by HH					
No school (n=64)	30 (6.7)	34 (7.3)	8.11 [3.21, 18.09]	9.09 [2.78, 20.06]	<0.001
Primary (n=624)	304 (48.72)	319 (68.3)	2.01 [1.08, 4.11]	1.87 [0.83, 3.03]	<0.001
Secondary and above (n=203)	99 (48.77)	104 (22.3)	1.53 [1.32, 3.05]	1.57 [1.07, 4.89]	0.001
Above secondary (n=17)	13 (77.78)	4 (0.9) (ref)			
Access better market					
No	331 (74.2)	376 (78.6)	1.69 [0.51,0.95]	1.29 [0.18, 2.41]	0.0207
Yes	116 (26)	91 (19.5) (ref)			
Child health indicators					
Presence of oedema					
No	380 (85.2)	349 (74.7) (ref)			
Yes	10 (2.2)	31 (6.6)	3.38 [1.62, 7.03]	2.50 [1.31, 4.08]	0.0006
Childhood infections					
No	365 (81.8)	306 (65.5) (ref)			
Yes	25 (5.6)	74 (15.8)	3.53 [2.17, 5.75]	1.45 [1.09, 2.03]	<0.001
Food insecurity					
Lack of food any month					
No	115 (25.8)	87 (18.6) (ref)			
Yes	333 (74.7)	380 (81.4)	1.51 [1.1, 2.07]	1.31 [1.01, 1.87]	0.01
Purchase food on credit					
No	392 (87.9)	383 (82) (ref)			
Yes	56 (12.6)	84 (18)	1.53 [1.06, 2.22]	1.48 [1.40, 1.74]	0.02
Begged food					
No	393 (88.1)	385 (82.4) (ref)			
Yes	55 (12.3)	82 (17.6)	1.52 (1.05, 2.2)	1.55 [1.21, 2.10]	0.03
Complementary feeding for children					
Exclusive breast feeding					
No	231 (51.8)	321 (68.7)	4.49 [3.7, 6.5]	5.45 [4.33, 7.61]	<0.001
Yes	204 (45.7)	139 (40.52) (ref)			
Plain water					
No	115 (25.8)	80 (17.1) (ref)			
Yes	308 (69)	360 (77)	1.68 [1.21, 2.33]	1.59 [1.18, 2.41]	0.0016
Powdered milk					
No	423 (94.8)	456 (97.6) (ref)			
Yes	12 (2.7)	4 (0.9)	0.31 [0.10, 1]	0.63 [0.36, 1.32]	0.033
Juices					
No	402 (90.1)	441 (94.4) (ref)			
Yes	33 (7.4)	19 (4.1)	0.52 [0.29, 0.94]	0.44 [0.12, 0.96]	0.027
Sugary foods					
No	400 (85.8)	413 (88.9)			
Yes	66 (14.8)	47 (10.1) (ref)	0.64 [0.43, 0.95]	0.66 [0.40, 0.99]	0.03
Mother's dietary intake					

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Milk and milk products					
No	413 (92.6)	453 (97)	2.6 [1.2, 5.8]	3.1 [2.1, 4.7]	0.0004
Yes	28 (6.3)	8 (1.7) (ref)			
Sugar and sweetened beverages					
No	375 (84.1)	423 (90.6) (ref)			
Yes	66 (14.8)	38 (8.1)	0.51 [0.33, 0.78]	0.48 [0.25, 0.70]	0.0016
Consumption of 5 or more food groups (MDD-W)					
No	370 (83)	412 (88.2)	3.62 [3.02, 6.2]	4.8 [1.9, 16.4]	0.016
Yes	71 (15.9)	49 (10.5) (ref)			

(ref.) = reference, OR = Odd Ratio, CI = Confidence Interval

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