

Prevalence and determinants of undernutrition among children of local farmers in central Malawi

Emmanuel Chilanga (✉ echilanga@gmail.com)

Research article

Keywords: Undernutrition, Risk factors, Child health, Central Malawi

Posted Date: January 28th, 2020

DOI: <https://doi.org/10.21203/rs.2.21952/v1>

License:  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Background Child undernutrition is a public health problem in Malawi. In 2015, about 23% of child mortality was linked to the phenomenon. Child undernutrition is more prevalent in rural areas and there is limited data to inform rural-specific programs. The aims of this study are to examine the prevalence and risk factors of undernutrition among 0-59 months-old children in rural central Malawi.

Methods A cross-sectional study design was used. A total of 538 child/mother dyads were systematically selected from postnatal clinics. Anthropometric assessment techniques and socio-demographic questionnaire was used to collect data. Child Z-scores for anthropometric data were calculated using World Health Organization's (WHO) anthro v3.2.2. Logistic regressions were used to determine correlates of undernutrition.

Results The rates of stunting, underweight, and wasting were 42%, 11%, and 3%, respectively. In multivariable logistic regression models, household limited access to safe water, and maternal exposure to intimate partner violence (IPV) were risk factors of child stunting (OR = 1.72, CI : 1.13-2.61) and (OR = 1.505, CI : 1.001-2.261) respectively. Child deworming, born at a low weight, and household food insecurity were some of risk factors of child underweight (OR = 2.14, CI: 1.18-3.89), (OR = 2.41, CI : 1.23-4.71), and (OR = 1.89, CI : 1.01-3.51) respectively. Households that were near domestic water supply had low risk of registering wasted children than households that were far from water supply (OR = 0.18, CI: 0.41-0.79).

Conclusions Only the prevalence of child stunting is greater in central Malawi compared to national level. This study suggest that programs that can promote access to potable water, food security, child deworming, improving child birth weight, and reduction of IPV against mothers can reduce the risk of child undernutrition.

1. Background

Child undernutrition is a pathological state mainly caused by an insufficient consumption of energy and nutrient-dense foods and frequent exposure to infectious diseases (1). The phenomenon compromises a child's growth and functioning and consequently reduces their human productivity in adulthood. Globally, undernutrition among children under five years old in the form of stunting, underweight, and wasting is a public health problem that underpins related development challenges in the Global South. In 2017, approximately 22.2% and 7.5% of children worldwide were stunted and wasted respectively (2). The burden of child undernutrition is pervasive in Malawi despite the country adopting strategic plans such as a national nutrition policy and farm subsidies (3). Current statistics show that 37% of the under five-years-old children are too short for their age (stunting), 3% are too thin for their height (wasting), and 12% are too thin for their age (underweight) (4).

The Government of Malawi has renewed its commitment to avert child undernutrition by signing the United Nations' 2030 Development Agenda. Accordingly, therapeutic and preventative child nutritional

programs have become available in clinical and community centers, including in rural areas (5). Children in rural areas of Malawi are at a higher risk of undernutrition compared to children in urban areas. In particular, the prevalence of stunted children is higher in the rural central region compared to the southern and northern regions (6). Therefore, continued surveillance of child nutritional status in rural central Malawi is crucial as it can provide evidence based data for planning and evaluation of local nutritional programs. This study contributes to the literature on child undernutrition and nutritional program development by examining the prevalence and risk factors of child undernutrition in the rural agrarian communities of Dowa district in central Malawi. Furthermore, the findings can potentially inform the development of child nutrition sensitive policies and interventions in the study areas.

2. Conceptual Framework

My study is guided by the UN Children's Fund's (UNICEF) "care for nutrition" conceptual framework (7,8). The model maintains that child undernutrition in developing countries is caused by a nexus of biological and social factors that operate at three levels. At a personal level, insufficient food intake and exposure to infectious diseases are core risk factors that cause child undernutrition. Household food insecurity (HFI), low dietary diversity, unhygienic environments, inadequate access to basic health services, and poor care for children and women are underlying factors that exacerbate this phenomenon. The third risk factors for child undernutrition operate at a macro level as well. They include cultural and political ideologies, national resource control, and economic mismanagement (7).

Drawing upon UNICEF's "care for nutrition" framework, studies in Malawi suggest that notable risk factors for child undernutrition are child morbidity, child age, and low birth weight (9). Common maternal underlying factors of child undernutrition include low education, young age at conception, and low body weight (10). At the household level, underlying factors of child undernutrition include low expenditure on food, low household income, and poor market access. At the community level, being in matrilineal lineage societies and drinking unclean water increase the risk of child undernutrition (11). The studies suggest that risk factors of child undernutrition in Malawi vary across geographical location. Therefore, there is a need for research in Malawi's various regions; to date; Dowa District in Central Malawi has received little attention from researchers. This article addresses the regional gap and contributes to the broader picture of the determinants of child undernutrition in rural agrarian areas of Malawi, with relevance to similar contexts elsewhere in sub-Saharan Africa.

3. Methods

Study location

The study was conducted in Malawi, a small landlocked country of about 118,484 km² in Sub Sahara Africa. Malawi is bordered by Mozambique to the South and East, Zambia to the West, and Tanzania to the North. The current population of Malawi is about 17,563,749 million and nearly 85% depend on agriculture for their livelihood (12). This research was conducted in six outreach clinics in rural

communities that are within the radius of 5 to 10 kilometers away from Mvera Mission Hospital in Dowa district (Fig. 1) during the months of May to September 2018.

Figure 1. The research setting

>>>>>Insert Fig. 1 here<<<<<<

Study sample

I employed a descriptive cross-sectional study design. A multi-stage cluster sampling technique was used to select representative research participants (13). Specifically, I randomly selected six out of eight outreach postnatal clinics that operate under Mvera Mission Hospital. The selected outreach clinics were Mkhalanjoka, Gogo, Mvera, Kalinyengo, Mphande, and Ching'amba. During the time of the study, Mvera hospital was serving a population of 27,719 people. Out of the total population, 4820 under-five year old child/mother dyads were clients of postnatal health services in the selected six-outreach clinics. A Raosoft online software program was used to calculate a sample size (14). The margin of error was set at 5%, with 95% confidence level, and a response distribution of 50%. The minimum sample size was found to be 356 under five-years-old child/mother dyads. I chose to increase my sample size to 538 dyads with an aim of strengthening the study's reliability and reducing the margin of error from 5–4%. A systematic sampling technique was used to select 538 out of 4,820 under-five child/mother dyads from postnatal registers by selecting every ninth pair starting with a randomly selected pair.

Participant recruitment

I contacted the selected children and their mothers through their postnatal clinics when they were attending a regular monthly health assessment. Health workers asked the mothers if they would be interested in participating in the study following their health assessment in a private consultation room. Five mothers did not consent to take part in the study, and they were subsequently replaced by randomly selected child-mother dyads that were not chosen during the initial sampling stage. For those who consented, a research assistant who was also a health worker orally administered the questionnaire in the same consultation room, away from the other health workers and clients. Through this set-up, the research team was able to protect the confidentiality of children and their mothers.

Measures

Outcome variables

The primary outcome variable of this study was child undernutrition in the form of stunting, underweight, and wasting. Stunting refers to a chronic form of undernutrition that entails prolonged periods of insufficient nutrient intake and assimilation (15). In general, stunting is an indicator of overall community social-economic wellbeing, where there is enough accessible food for the child to consume (16). Wasting refers to an acute form of undernutrition and entails a deficit of body tissue and fat mass. The condition arises when a child fails to access adequate food nutrients within a short period of time (15).

Underweight is a composite measure of child undernutrition that encompasses both stunting and wasting. SECA gmbh & co. Model 874 mother-infant weighing scale was used to measure and collect the weight of the children and mothers. All standard practices for weighing children were followed, which included children wearing minimal clothing and no shoes when they were weighed (17). For accuracy and consistency, a 2 kg weight was used to adjust the measuring scale to zero after weighing each mother-child pair. The results of child and maternal weight were calculated to the nearest 100 grams. Length measuring boards were used to take children's height and were recorded to the nearest 0.1 cm (18). Children who were two or more years old were measured in a standing position while those that were less than two years old were measured in a recumbent position.

I calculated height-for-age, weight-for-height, and weight-for-age Z-score values from measured children's heights, weights, age in months and reported child sex. A WHO Anthro software version 3.2.2, January, 2011 (19) was used to calculate the Z-scores with reference to the WHO child growth standards (20). Child stunting, underweight, and wasting were denoted as those that were less than or equal to 2 standard deviations of height-for-age, weight-for age, and weight-for-height Z-scores (18).

Independent variables

Based on UNICEF's "care for nutrition" conceptual framework, I included numerous explanatory variables that have been linked to child undernutrition in developing countries (21). The following immediate child risk factors were considered as potential explanatory variables. Normal childbirth weight (≥ 2.5 kg) was coded zero, and low birth weight (< 2.5 kg) was recorded = one. Common child morbidities in the study areas were diarrhea, malaria, and acute respiratory infection (ARI). Mothers were asked to report the common sicknesses that the child suffered from in the two weeks prior to the research. Mothers' reported child morbidity was ascertained in the child health passport book as examined by medical personnel on the day that corresponded with the survey. I coded 1 = diagnosed/reported sicknesses and 0 = no sickness in the past two weeks. Child gender was coded as 0 = female, and 1 = male. Children who were treated with deworming drugs such as albendazole within the past year were coded = 1 and those who did not receive the treatment were coded = 0. Age of children were categorized as 1 = 1–5 months, 2 = 6–11 months, 3 = 12–23 months, and 4 = 24–59 months old.

The first underlying risk factors of child undernutrition were maternal demographic characteristics. They included age which was coded as 1 = 16–24 years old, 2 = 25–34, and 3 = 35–49. Maternal education was categorized as 0 = no education, 1 = primary school, and 2 = secondary school. Maternal faith was categorized as 1 = Church of Central African Presbyterian (CCAP), 2 = Catholic, and 3 = Pentecostal. The number of children that a mother gave birth to were coded as 1 = one, 2 = two, 3 = three, 4 = four, and 5 = five and more. I also considered whether the pregnancy for the child participant was planned or unplanned. I coded 0 = planned, and 1 = unplanned. Mothers' nutritional status was categorized as 1 = underweight ($\text{BMI} < 18.5 \text{ kg/m}^2$), 2 = normal ($\text{BMI} 18.5\text{--}24.9 \text{ kg/m}^2$), 3 = overweight ($25.0\text{--}29.9 \text{ kg/m}^2$), and 4 = obesity ($\geq 30.0 \text{ kg/m}^2$) (18). Mothers who received nutritional counselling during pregnancy were coded 1 = yes and 0 = no. I also assessed whether a mother was exposed to IPV which was coded as 1 =

yes and 0 = no. IPV was assessed by using a WHO Multi-country study questionnaire on women's health and life experiences that was previously validated and administered in Malawi (22,23).

The second underlying risk factors of child undernutrition were attributed to the father. Amongst them was education which was coded 0 = no formal education, 1 = primary, and 2 = secondary and tertiary education. Age was coded as 1 = 15–24 years old, 2 = 25–34, and 3 = 35–49. We included fathers' risky health behaviours such as alcohol consumption, smoking, whether he was involved in polygamous family, infidelity, and/or divorced. Each risk behavior was coded as 0 = no and 1 = yes.

Poverty threshold as a household level underlying risk factor for child undernutrition was defined based on the international poverty headcount ratio of USD 1.90 a day (24). Household food security was measured by a Household Food Insecurity Access Scale (HFIAS), which is calculated based on responses to questions about the frequency of occurrence of nine experiences characteristic of food security in the past month (25). Whereas the HFIAS yields four categories of food security, I coalesced the four HFIAS categories into food secure (food secure and mildly food insecure) and food insecure (moderately and severely food insecure) households to produce a binary set of categories (0 = food secure and 1 = food insecure household). The nutritional quality of diets was measured by Household Dietary Diversity Scale (HDDS) (18,26). I coded household as 1 = inadequate household dietary diversity when the mother reported that they consumed four or less food groups in the past 24 hours and 0 = adequate household dietary diversity when a mother reported that they consumed five or more food groups in the past 24 hours (18,27). I also inquired about household domestic water source. I coded 1 = borehole (potable water) and 0 = river/wells (unsafe water). I also considered time that the mother took to fetch a pail of water. This was coded as 0 = < 30 minutes, and 1 = ≥ 30 minutes. I considered child delivery place as hospital = 1, and home or traditional birth attendant = 0. I did not include toilet facility and household type because almost 99% and 98% of participants reported having an open pit latrine and grass thatched houses respectively.

The survey was administered on Android tablets. The Open Data Kit (ODK) was used to upload the digital version of the questionnaire into the tablets. An ODK is an Android application that can administer surveys, collect, and organize the survey data (28). This application allows for immediate data validation in the field. My team (the research trainers) included a clinical officer, a medical doctor, and a PhD social work candidate. Nine married female health surveillance assistants (research assistants) that were trained using the WHO protocol for conducting studies of IPV were responsible for data collection (29,30). It took five days to train the research assistants and to pretest the survey questionnaire. The research assistants and trainers all had professional training in child and maternal health. The researcher stakeholders also had vast experience in measuring child weight and height and diagnosing common child illnesses in Malawi. Since I examined a sensitive topic relating to IPV, stakeholders decided that the questionnaire should be administered in the clinic's consultation room (31,32). The procedure for recruitment was as follows: when a mother and her child completed their monthly postnatal primary healthcare check-up, a health worker on-duty informed the mother about my nutritional study. If the mother was interested to take part in the research, the health worker invited the survey enumerator to

administer the questionnaire. The arrangement was agreed upon by the survey team in consultation with hospital officials in order to maximize confidentiality of the research participants. Research assistants explained the objectives of the research and when the mother agreed to participate, she was requested to affirm her consent verbally.

Research Ethics Review

I obtained ethics approval to conduct this study from McGill University's Research Ethics Board in Canada protocol number (REB File #: 503-0518), and University of Livingstonia research committee in Malawi protocol number (UNILIA-REC-4/18). I also obtained written permission from the authorities at the Dowa district Commissioner's office, the Dowa District Health Office, and Mvera Mission Hospital. Oral consent was also obtained from local health leaders.

Data analysis

All 538 selected child-mother pairs were assessed for nutritional status. Cronbach's α analysis was conducted to calculate the internal reliability of the questionnaire items that were used to determine HFS, dietary diversity, and IPV (33). The HFIAS' 9 items ranged in severity from worrying about household access to food to going the whole day and night without consuming any food due to lack of resources (34,35). The HDDS had 12 food categories which were used to probe the type of food that household members consumed in the past 24 hours. The scales on IPV controlling behavior had five items, psychological abuse had four items, physical abuse had six items, and sexual abuse had three items. I considered an α level of 0.70 or higher as satisfactory (33). The calculated Cronbach's α for the HFIAS was 0.87, 0.83 for the HDDS, while the Cronbach's α for the controlling behavior items was 0.81, psychological violence was 0.75, physical violence was 0.83, and sexual violence was 0.87.

I used the Kolmogorov-Smirnov test to determine the normality of the distribution of numerical variables that included age, number of children, and HFIAS. It was found that my data was not normally distributed and opted to construct numerical variables into categories according to standard procedures (36). I calculated the determinants of stunting, wasting, and underweight based on socio-demographic characteristics of children, mothers, fathers, and household factors. A chi-square test was used to examine the association between indicators of each form of child undernutrition and given explanatory variables. Univariate logistic regressions were also performed to determine significant risk factors of child undernutrition from the selected independent variables. Three separate multivariable logistic regression analyses were performed to explore predictors of child stunting, underweight, and wasting. Variables that were significant at a bivariate level were entered into the final multivariable logistic regression models using forward method.

Multicollinearity of explanatory variables was tested and a variance inflation factor (VIF) of 5.342 was obtained. The VIF was less than ten and I was confident that the included independent variables were not similar. Therefore, my regression coefficients estimates were reliable (37). I have reported the results of each of the three-child undernutrition multivariable analyses models as crude and adjusted odds ratios

(AORs) with a 95% confidence interval (CI). A p value was considered statistically significant when it was less than 0.05. An IBM Statistical Package of Social Sciences (SPSS) for Windows version 23.0 (IBM Corp., Armonk, NY, USA) was used to analyze the data.

4. Results

Sociodemographic characteristics of study population

A total of 538 children, aged 0 to 59 months, were included in this study. More boys (51%) were sampled than girls (49%). The gender difference reflected the trends in the general population of children under five years old as hospital registers showed that more boys than girls were born in the past five years.

Regarding children's age range, 13.4% were between 1 to 5 months, 16.7% were between 6 to 11 months, 29.0% were between 12 to 23 months, and 40.9% were between 24 to 59 months old. The study found that 35%, 40.1%, and 30.3% of the recruited children were diagnosed with malaria, ARI, and diarrhea in the two weeks prior to the study respectively. The mean age of mothers was 27.6 years old (SD = 7). It was found that 31% of the mothers had one child, 23% had two children, 20% had three children, 11% had four children, and the remaining 15% of mothers had five or more children. In terms of education attainment, about 70% of mothers had primary school education, 16% had a secondary education, and 15% had no formal education. The study found that 16.2% of fathers were in the age range of 15 to 24 years old, 45.5% were in the age range of 25 to 34, and 38.3% were in the age range of 35 to 49. In terms of health risk behaviors, the study found that 26% of fathers were tobacco smokers, 22% had polygamous families, 43% consumed alcohol, and 30% had concubines. The results also showed that 127 (23.6%) of fathers divorced a wife.

At the household level, 97.5% of the households were below the poverty line of \approx USD 1.90/day per adult person. It was also found that about 60% of the households were food insecure, while 66% had inadequate dietary diversity. In terms of access to domestic water, 29.4% of the households did not have access to clean water. In addition, 42% of mothers were spending \geq 30 minutes to obtain and transport clean water. Table one highlight selected sociodemographic factors of my sample.

Table 1

Table 1
Socio-demographic characteristics of study sample

Mothers characteristics	Age (years)	N = 538	%
	15–24	224	41.6
	25–34	209	38.8
	35–49	105	19.5
	Education		
	No education	81	15.1
	Primary	370	68.8
	Secondary	87	16.2
	BMI		
	Underweight	27	5.0
	Normal	323	60.0
	Overweight	150	27.9
Children's characteristics	Sex		
	Female	263	48.9
	Male	275	51.1
	Age range		
	1–5	72	13.4
	6–11	90	16.7
	12–23	156	29
	24–59	220	40.9
	Diarrhea episode	163	30.3
	ARI episode	216	40.1
Fathers' characteristics	Age category		
	15–24	87	16.2
	25–34	245	45.5
	35–49	206	38.3
	Current smoker	138	26.0
	Ever divorced a wife	127	23.6

The findings of unadjusted logistic regressions (Table 2, crude models 1, 2, and 3) show that being a male child, accessing unsafe water, mother's exposure to IPV, low household dietary diversity, mothers' lack of access to nutritional counseling, children who reside in families where fathers divorced a wife, and unplanned pregnancy were risk factors of child stunting. Household limited access to safe water, low child birthweight, HFS, and child-limited access to deworming drugs were risk factors of child underweight. Finally, only children whose mothers took more than thirty minutes to access water were at high risk of wasting than children whose mothers took less than 30 minutes.

Table 2

Crude and adjusted odds ratios (95% CI) for factors associated with child undernutrition in Dowa

Variables	Model 1 Stunting		Model 2 Underweight		Model 3 Wasting	
	Crude OR	AOR	Crude OR	AOR	Crude OR	AOR
Child sex						
Male	1	1	1	1	1	1
Female	0.66***	0.65*	0.92	0.94	0.93	0.76
Water source						
River	1	1	1	1	1	1
Borehole	0.67*	0.58**	0.56*	0.47**	0.73	0.80
Exposed to IPV						
Yes	1	1	1	1	1	1
No	0.68*	0.59***	0.86	0.93	0.57	0.62
Dietary Diversity						
Average	1	1	1	1	1	1
Low	1.64***	1.34	1.87	1.84	2.23	1.99
Nutrition information						
Yes	1	1	1	1	1	1
No	3.22***	3.50***	1.00	1.02	2.12	2.08
Husband divorced						
No	1	1	1	1	1	1
Yes	1.51*	1.66	1.87*	1.72	2.26	2.00
Unplanned pregnancy						
Yes	1	1	1	1	1	1
No	0.69*	0.69	0.64	0.78	0.66	0.88
Time taken to fetch water						
≥ 30 Minutes	1	1	1	1	1	1

*p < .05; **p < .01; ***p < .0001.

Variables	Model 1 Stunting		Model 2 Underweight		Model 3 Wasting	
	Crude OR	AOR	Crude OR	AOR	Crude OR	AOR
≤30 minutes	0.98	0.87	0.42***	0.50*	0.18*	0.25*
Child birth weight						
Normal	1	1	1	1	1	1
Low	1.32	1.39	2.47***	2.55***	2.64	2.93
Household food security						
Secure	1	1	1	1	1	1
Insecure	1.09	1.16	1.88*	1.92*	1.25	2.05
Child received Albendazole						
Yes	1	1	1	1	1	1
No	1.13	1.02	1.74*	1.82*	1.08	1.25
*p ≤ .05; **p ≤ .01; ***p ≤ .0001.						

In multivariable regression analyses, I adjusted for all variables that were significant predictors of child undernutrition in the prior models. The results of multivariable logistic regression of child stunting (Table 2, Model 1) show that boys were at an increased risk of stunting (AOR: 1.54, 95% CI: 1.06–2.23, $P < 0.023$) compared to girls. Furthermore, children from households that use unsafe water had an increased risk of stunting (AOR: 1.72, 95% CI: 1.13–2.61, $P < 0.011$) than children from households that used potable water. Children born from mothers who received nutritional education during gestational period had low risk of stunting (AOR: 0.29, 95% CI: 0.14–0.59, $P < 0.001$) than children born from mothers who did not receive nutritional education when they were pregnant. Children who were residing in households that mothers experienced IPV were at an increased risk of stunting (AOR: 1.69, 95% CI: 1.14–2.49, $P < 0.009$) compared to children whose mothers did not experience IPV.

The results of multivariable logistic regression analyses of underweight children (Table 2, Model 2) shows that children whose fathers have divorced were more likely to be underweight (AOR: 1.88, 95% CI: 1.02–3.48, $P < 0.044$) than children whose fathers never divorced a wife. Children from families that used potable water were less likely to be underweight (AOR: 0.50, 95% CI: 0.28–0.90, $P < 0.021$) than children from families that used unsafe water. Children whose mothers spent less than 30 minutes to access water were less likely to be underweight (AOR: 0.44, 95% CI: 0.23–0.83, $P < 0.011$) than children whose mothers spent 30 minutes or more. It was also observed that children from food insecure households had higher chances of being underweight (AOR: 1.89, 95% CI: 1.01–3.53, $P < 0.047$) than children from food secure households. In addition, children whose birthweight were less than 2.5kgs were at an increased

boreholes are safe because are within WHO and Malawi Bureau of Standards quality limits. Furthermore, the studies maintain that approximately 80% of well water in Malawi is unfit for human consumption. Specially, faecal coliforms that cause typhoid, diarrhea, and cholera are prevalent forms of pathogens in these open water sources (43,44). Therefore, the observed stunting in children who used unsafe water from rivers or wells can be partially attributed to recurrent illness from waterborne diseases such as diarrhea (45).

In this study, I have found that children from families that accessed domestic water within 30 minutes were less likely to be underweight and wasted compared to children from families that took more than 30 minutes to access water. There are two possible explanations for this result. Firstly, studies suggest that the longer mothers take to collect water, the less time they have to care for their children (46), including providing regular breastmilk and frequent meals (47,48). The second reason for the child nutritional outcome is related to household hygiene. Studies suggest that good hygienic practices are inversely related to distance from the water source. This means that households that are far away from the water source are more likely to be engaged in unhygienic childcare practices such as reduced laundry and unhygienic food preparation practices. These basic sanitary practices directly exacerbate poor child nutrition and health outcomes (49–51).

My study support current findings in Malawi that low birthweight is a risk factor of child undernutrition (52). As observed in this study, children born with low birth weight were 2.6 times more likely to be underweight than children who were born within the normal weight range. The explanation of the finding can be drawn from the literature which suggests that children who suffered intrauterine growth retardation as fetuses are more likely to be undernourished compared to children without such a condition (53,54). Furthermore, the phenomenon is intergenerational as maternal undernutrition, maternal underweight, and low stature exacerbate a low child birthweight. Therefore, the issue of underweight children can be addressed through programs that specifically ensure that girls, women, and pregnant mothers are adequately nourished, while also focusing on the first 1000 days of children's lives (55,56).

This study has also found that children who did not receive intestinal deworming drugs such as albendazole in the year prior to the study were 1.8 times more likely to be underweight than children that were dewormed. This finding supports the importance of child deworming programs that are underway in Malawi and other developing countries (57). There is no study that has been done in the study areas on the nutritional benefits of child deworming, but a randomized study in Southern Malawi did not find any significant benefits of the treatment (58). These two conflicting studies from Malawi confirm the global literature that shows inconclusive benefits of child deworming (59–61). For instance, a study in India reported that under five-years-old children who received albendazole significantly gained an average weight of 3.04 kg than untreated children (62). However, a recent literature review suggests that child deworming has little or no impact on child weight in many low and middle income countries (63). Therefore, more research is needed in my study area to validate this finding.

The study has also found that children from food insecure families were 1.9 times more likely to be underweight than children from food secure households. The finding supports the available literature in developing countries that link HFI and child undernutrition. For instance, studies in Kenya and India found that household food insecurity was a risk factor for child stunting, wasting, and underweight (64,65). Similarly, a study that was conducted in Nicaragua found that even mild household food insecurity was detrimental not only to child nutrition but general child wellbeing (66).

Finally, this study has found that sex of children predicted child stunting but not wasting and underweight. Specifically, girls were 0.65 less likely to be stunted than boys. The result agrees with the current findings of the national study in Malawi where 39% of the boys and 35% of girls under five years old were stunted (4). Likewise, studies suggest that young boys in SSA countries are at an increased risk of stunting (OR 1.16) than young girls (67,68). The sex-related difference in child stunting requires further study in the study areas. Specifically, it is inconclusive whether behavioral factors such as a gender bias, in terms of preferential treatment of girls over boys, can explain the difference (69,70). In biology, the evolution theory speculates that natural selection favors a 1.0 sex ratio (71). In my study area, there were more boys (51%) than girls (49%). Therefore, based on evolution concepts, girls are more likely to survive in this area than boys despite being exposed to the same environmental stressors (72).

Conclusion and recommendations

The study has found that the prevalence of stunted children is higher in the study areas as compared to national prevalence. The prevalence of underweight and wasting are within the range of the national rate. The notable risk factors for child stunting include being a male child, access to open water sources, mothers' exposure to IPV controlling behavior, and lack of nutritional counselling during the gestational period. The study also suggest that limited access to portable water, low child birthweight, household food insecurity, and non-dewormed children were associated with child underweight. Finally, the study found that longer time that mothers took to fetch water increased the risk of child wasting.

This study suggest that on top of already existing child nutrition promotion programs in the study areas, there is also a need to consider improving household water access. Such programs can free up childcare givers who are mostly mothers to have ample time to dedicate to their childcare activities. I also recommend that a holistic approach should be taken to address child undernutrition in the study areas. Programs that improve household food security, low child birthweight, access to nutritional education, and increased child deworming can have positive impact on child nutrition. Furthermore, child undernutrition in Malawi should be perceived as a problem that can be addressed by all policy stakeholders. Specifically, the Ministry of Health, Agriculture, Economics, Education, and Water among others should collaborate to address these issues at hand.

I also suggest that IPV against mothers of children under five years old should also be considered as one of the risk factors of child undernutrition. Fathers' controlling behavior towards mothers should be addressed as it may potentially minimize maternal access to social networks that can be used to support

the child. As such, counselling should be given to couples to reduce incidences of divorce that seems to have an impact on child nutrition, in addition to dealing with IPV.

Strengths and Limitations

This study used the WHO reference group to measure the prevalence of child undernutrition in rural areas of central Malawi. Therefore, the results are comparable to national and global studies. Nevertheless, this study had some limitations. Since this is a cross-sectional study, I do not claim that the identified risk factors cause child undernutrition. In addition, some of the socio-demographic factors that were controlled were obtained retrospectively. Therefore, it is possible that a recall bias resulted in over or under reporting of some variables. Finally, I did not have control over social desirability bias that could emanate from the responses of the research participants (73). Some of the questions such as exclusive breastfeeding, child complementary feeding, and sleeping under mosquito nets were asked. It could be possible that a section of mothers accepted these childcare practices to appease the health workers who were my research assistants.

Abbreviations

AOR

Adjusted odds ratios

COR

Crude odds ratios

CCAP

Presbyterianism

CI

Confidence interval

HDDS

Household Dietary Diversity Scale

HFI

Household food insecurity

HFIAS

Household Food Insecurity Access Scale

IPV

Intimate partner violence

NSO

National Statistics Office

SRQ

Self reporting questionnaire

SSA

Sub Sahara Africa

US\$

Declarations

Ethics approval and consent to participate

The author received research ethics approval from the Non-Medical Research Ethics Board at University of Livingstonia in Malawi (UNILIA-REC-4/18), and at McGill University, Canada (REB File #: 503-0518). The study also received written consent from Dowa district health office. Informed consent were obtained from all participants before each interview.

Consent for publication

The author informed the participants that the study will be published to partially fulfill the requirement for the PhD. With full understanding of the research and its intended purpose, all participants gave full consent for me to disseminate the results through publication.

Availability of data and materials

The study involved capturing of sensitive data according to WHO standards. I documented mothers' disclosure of violence by their current husbands. Due to the sensitivity of the study the two ethics boards did not recommend sharing the raw data publicly.

Competing interests

I declare no competing interests

Funding

The fieldwork was financed with grants from the International Development Research Centre of Canada (IDRC), McGill Global Health Programs, and Queen Elizabeth Advanced Scholars. The funding bodies did not take any role in the design, data collection, analysis, interpretation, and publication of the study.

Authors' contributions

EC conceptualized and designed the study, collected, analyzed the data, and wrote the first draft of the manuscript. EC reviewed and approved the final version of the manuscript.

Acknowledgements

I gratefully appreciate the role of my supervisor Dr. Delphine Collin-Vezina, and entire PhD candidacy committee members Dr. Heather MacIntosh and Dr. Claudia Mitchel of McGill University for their support

in mentoring me to develop the PhD dissertation in which this study came from. I also extend my appreciation to Health Surveillance Assistants at Mvera hospital for taking part in data collection as research assistants. Many thanks to Arkford Mkundika of Sheffield Hallam University (UK) for cartographic assistance.

References

1. Crowe S, Seal A, Grijalva-Eternod C, Kerac M. Effect of nutrition survey 'cleaning criteria' on estimates of malnutrition prevalence and disease burden: secondary data analysis. *PeerJ*. 2014 May 13;2:e380.
2. World Health Organization. Levels and trends in child malnutrition: Key findings of the 2018 Edition of the Joint Child Malnutrition Estimates. Geneva; 2018 p. 1–16.
3. Malawi Ministry of Health. National Multi-Sector Nutrition Policy 2018-2022. Lilongwe: Ministry of Health; 2018 p. 1–76.
4. NSO. Malawi Demographic and Health Survey 2015-16. Zomba, Malawi, and Rockville, Maryland, USA. NSO and ICF: National Statistical Office (NSO) [Malawi] and ICF.; 2017.
5. Stobaugh HC, Bollinger LB, Adams SE, Crocker AH, Grise JB, Kennedy JA, et al. Effect of a package of health and nutrition services on sustained recovery in children after moderate acute malnutrition and factors related to sustaining recovery: a cluster-randomized trial. *Am J Clin Nutr*. 2017;106(2):657–66.
6. NSO. Malawi Demographic and Health Survey 2015-16. Zomba, Malawi, and Rockville, Maryland, USA. NSO and ICF: National Statistical Office (NSO) [Malawi] and ICF; 2017.
7. Engle PL, Bentley M, Pelto G. The role of care in nutrition programmes: current research and a research agenda. *Proc Nutr Soc*. 2000 Feb;59(1):25–35.
8. Engle PL, Pelto G, Bentley P. Care for nutrition and development. *J Indian Med Assoc*. 2000 Sep;98(9):530–5.
9. Doctor HV, Nkhana-Salimu S. Trends and Determinants of Child Growth Indicators in Malawi and Implications for the Sustainable Development Goals. *Aimsph* 2017 Vol 4 Pages 590-614 [Internet]. 2017 [cited 2018 Dec 12]; Available from: <http://www.aimspress.com/article/10.3934/publichealth.2017.6.590/fulltext.html>
10. Ntenda PAM, Chuang Y-C. Analysis of individual-level and community-level effects on childhood undernutrition in Malawi. *Pediatr Neonatol*. 2018;59(4):380–9.
11. Chikhungu LC, Madise NJ, Padmadas SS. How important are community characteristics in influencing children's nutritional status? Evidence from Malawi population-based household and community surveys. *Health Place*. 2014;30:187–95.

12. NSO. 2018 Malawi Population and Housing Census Preliminary Report. Zomba, Malawi, and Calverton, Maryland, USA; 2018 Dec.
13. Remler DK, Ryzin GGV. *Research Methods in Practice: Strategies for Description and Causation*. SAGE Publications; 2014. 1462 p.
14. McCrum-Gardner E. Sample size and power calculations made simple. *Int J Ther Rehabil*. 2010 Jan 1;17(1):10–4.
15. Briend A, Khara T, Dolan C. Wasting and Stunting—Similarities and Differences: Policy and Programmatic Implications. *Food Nutr Bull*. 2015 Mar 1;36(1_suppl1):S15–23.
16. Onis M de, Branca F. Childhood stunting: a global perspective. *Matern Child Nutr*. 2016;12(S1):12–26.
17. de Onis M, Blössner M. The World Health Organization Global Database on Child Growth and Malnutrition: methodology and applications. *Int J Epidemiol*. 2003;32(4):518–26.
18. Malawi Ministry of Health. *National Guidelines on Nutrition Care, Support, and Treatment (NCST) for Adolescent and Adults*. Second edition. Lilongwe; 2017 p. 1–106.
19. WHO and Macros. *WHO Anthro (version 3.2. 2, January 2011) and macros*. Geneva, Switzerland: World Health Organization; 2011.
20. Pimenta FS, Oliveira CM, Hattori WT, Teixeira KR, Pimenta FS, Oliveira CM, et al. Agreement between Subjective Global Nutritional Assessment and the nutritional assessment of the World Health Organization. *J Pediatr (Rio J)*. 2018;94(6):602–8.
21. Danaei G, Andrews KG, Sudfeld CR, Fink G, McCoy DC, Peet E, et al. Risk Factors for Childhood Stunting in 137 Developing Countries: A Comparative Risk Assessment Analysis at Global, Regional, and Country Levels. *PLOS Med*. 2016;13(11):e1002164.
22. Fan AZ, Kress H, Gupta S, Wadonda-Kabondo N, Shawa M, Mercy J. Do self-reported data reflect the real burden of lifetime exposure to sexual violence among females aged 13–24 years in Malawi? *Child Abuse Negl*. 2016;58:72–9.
23. VanderEnde K, Mercy J, Shawa M, Kalanda M, Hamela J, Maksud N, et al. Violent experiences in childhood are associated with men’s perpetration of intimate partner violence as a young adult: a multistage cluster survey in Malawi. *Ann Epidemiol*. 2016;26(10):723–8.
24. Prydz DJEB. *Estimating International Poverty Lines from Comparable National Thresholds [Internet]*. The World Bank; 2016 [cited 2018 Dec 12]. 36 p. (Policy Research Working Papers). Available from: <https://elibrary.worldbank.org/doi/abs/10.1596/1813-9450-7606>
25. Coates J, Swindale A, Bilinsky P. *Household Food Insecurity Access Scale (HFIAS) for measurement of food access: indicator guide (v.3)*. Washington DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development; 2007 p. 1–32.
26. Swindale A, Bilinsky P. *Household Dietary Diversity Score (HDDS) for Measurement of Household Food Access: Indicator Guide (v.2)*. Washington, D.C: FHI 360/FANTA; 2006 p. 1–11.

27. Mekuria G, Wubneh Y, Tewabe T. Household dietary diversity and associated factors among residents of finote selam town, north west Ethiopia: a cross sectional study. *BMC Nutr.* 2017;3(1):28.
28. Hartung C. Open Data Kit: Technologies for Mobile Data Collection and Deployment Experiences in Developing Regions [PhD Thesis]. [Seattle, WA, USA]: University of Washington; 2012.
29. Ellsberg M, Heise L. Bearing witness: ethics in domestic violence research. *The Lancet.* 2002 May 4;359(9317):1599–604.
30. Ellsberg M, Heise L, Pena R, Agurto S, Winkvist A. Researching Domestic Violence against Women: Methodological and Ethical Considerations. *Stud Fam Plann.* 2001;32(1):1–16.
31. Bender AK. Ethics, Methods, and Measures in Intimate Partner Violence Research: The Current State of the Field. *Violence Women.* 2017;23(11):1382–413.
32. Tarzia L, Valpied J, Koziol-McLain J, Glass N, Hegarty K. Methodological and Ethical Challenges in a Web-Based Randomized Controlled Trial of a Domestic Violence Intervention. *J Med Internet Res [Internet].* 2017 [cited 2018 Nov 19];19(3). Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5388827/>
33. Nybergh L, Taft C, Krantz G. Psychometric properties of the WHO Violence Against Women instrument in a female population-based sample in Sweden: a cross-sectional survey. *BMJ Open [Internet].* 2013 [cited 2018 Nov 19];3(5). Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3664346/>
34. Desiere S, D’Haese M, Niragira S. Assessing the cross-sectional and inter-temporal validity of the Household Food Insecurity Access Scale (HFIAS) in Burundi. *Public Health Nutr.* 2015;18(15):2775–85.
35. Gebreyesus SH, Lunde T, Mariam DH, Woldehanna T, Lindtjørn B. Is the adapted Household Food Insecurity Access Scale (HFIAS) developed internationally to measure food insecurity valid in urban and rural households of Ethiopia? *BMC Nutr.* 2015;1(1):2.
36. Berger VW, Zhou Y. Kolmogorov–Smirnov Test: Overview. In: *Wiley StatsRef: Statistics Reference Online [Internet].* American Cancer Society; 2014 [cited 2018 Dec 16]. Available from: <https://onlinelibrary.wiley.com/doi/abs/10.1002/9781118445112.stat06558>
37. Daoud JI. Multicollinearity and Regression Analysis. *J Phys Conf Ser.* 2017;949(1):012009.
38. Girard AW, Olude O. Nutrition Education and Counselling Provided during Pregnancy: Effects on Maternal, Neonatal and Child Health Outcomes. *Paediatr Perinat Epidemiol.* 2012;26(s1):191–204.
39. Lopes K da S, Ota E, Shakya P, Dagvadorj A, Balogun OO, Peña-Rosas JP, et al. Effects of nutrition interventions during pregnancy on low birth weight: an overview of systematic reviews. *BMJ Glob Health.* 2017;2(3):e000389.
40. Bezner Kerr R, Dakishoni L, Shumba L, Msachi R, Chirwa M. “We Grandmothers Know Plenty”: Breastfeeding, complementary feeding and the multifaceted role of grandmothers in Malawi. *Soc Sci Med.* 2008;66(5):1095–105.
41. Riley L, Chilanga E. ‘Things are not working now’: poverty, food insecurity and perceptions of corruption in urban Malawi. *J Contemp Afr Stud.* 2018;0(0):1–15.

42. Simkhada B, Porter MA, van Teijlingen ER. The role of mothers-in-law in antenatal care decision-making in Nepal: a qualitative study. *BMC Pregnancy Childbirth*. 2010;10(1):34.
43. Mkwate RC, Chidya RCG, Wanda EMM. Assessment of drinking water quality and rural household water treatment in Balaka District, Malawi. *Phys Chem Earth Parts ABC*. 2017;100:353–62.
44. Smiley SL. Quality matters: incorporating water quality into water access monitoring in rural Malawi. *Water Int*. 2017;42(5):585–98.
45. Prüss-Ustün A, Bartram J, Clasen T, Colford JM, Cumming O, Curtis V, et al. Burden of disease from inadequate water, sanitation and hygiene in low- and middle-income settings: a retrospective analysis of data from 145 countries. *Trop Med Int Health*. 2014;19(8):894–905.
46. Koolwal G, van de Walle D. Access to Water, Women’s Work, and Child Outcomes. *Econ Dev Cult Change*. 2013 Jan 1;61(2):369–405.
47. Chilanga E. Assessing the Impact of Nutritional Education on Gender Roles and Child Care in Northern Malawi. *Electron Thesis Diss Repos [Internet]*. 2013 Jun 4; Available from: <https://ir.lib.uwo.ca/etd/1298>
48. Kerr RB, Chilanga E, Nyantakyi-Frimpong H, Luginaah I, Lupafya E. Integrated agriculture programs to address malnutrition in northern Malawi. *BMC Public Health*. 2016;16(1):1197.
49. Graham JP, Hirai M, Kim S-S. An Analysis of Water Collection Labor among Women and Children in 24 Sub-Saharan African Countries. *PLOS ONE*. 2016;11(6):e0155981.
50. Majuru B, Suhrcke M, Hunter PR. How Do Households Respond to Unreliable Water Supplies? A Systematic Review. *Int J Environ Res Public Health*. 2016;13(12):1222.
51. Usman MA, Gerber N, Braun J von. The Impact of Drinking Water Quality and Sanitation on Child Health: Evidence from Rural Ethiopia. *J Dev Stud*. 2018;0(0):1–19.
52. Ntenda PAM. Association of low birth weight with undernutrition in preschool-aged children in Malawi. *Nutr J*. 2019 Sep 2;18(1):51.
53. Sania A, Spiegelman D, Rich-Edwards J, Hertzmark E, Mwiru RS, Kisenge R, et al. The contribution of preterm birth and intrauterine growth restriction to childhood undernutrition in Tanzania. *Matern Child Nutr*. 2015;11(4):618–30.
54. Sharma D, Shastri S, Sharma P. Intrauterine Growth Restriction: Antenatal and Postnatal Aspects. *Clin Med Insights Pediatr*. 2016;10:CMPed.S40070.
55. Black MM, Merseth KA. First 1000 Days and Beyond: Strategies to Achieve the Sustainable Development Goals. In: Verma S, Petersen AC, editors. *Developmental Science and Sustainable Development Goals for Children and Youth [Internet]*. Cham: Springer International Publishing; 2018 [cited 2018 Dec 16]. p. 97–112. (Social Indicators Research Series). Available from: https://doi.org/10.1007/978-3-319-96592-5_5
56. Young MF, Nguyen PH, Casanova IG, Addo OY, Tran LM, Nguyen S, et al. Role of maternal preconception nutrition on offspring growth and risk of stunting across the first 1000 days in Vietnam: A prospective cohort study. *PLOS ONE*. 2018;13(8):e0203201.

57. Lo NC, Snyder J, Addiss DG, Heft-Neal S, Andrews JR, Bendavid E. Deworming in pre-school age children: A global empirical analysis of health outcomes. *PLoS Negl Trop Dis* [Internet]. 2018 [cited 2018 Dec 16];12(5). Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5997348/>
58. Wang AZ, Shulman RJ, Crocker AH, Thakwalakwa C, Maleta KM, Devaraj S, et al. A Combined Intervention of Zinc, Multiple Micronutrients, and Albendazole Does Not Ameliorate Environmental Enteric Dysfunction or Stunting in Rural Malawian Children in a Double-Blind Randomized Controlled Trial. *J Nutr*. 2017;147(1):97–103.
59. Croke K, Hicks JH, Hsu E, Kremer M, Miguel E. Should the WHO withdraw support for mass deworming? *PLoS Negl Trop Dis*. 2017 Jun 8;11(6):e0005481.
60. Harper KM, Mutasa M, Prendergast AJ, Humphrey J, Manges AR. Environmental enteric dysfunction pathways and child stunting: A systematic review. *PLoS Negl Trop Dis*. 2018;12(1):e0006205.
61. Taylor-Robinson DC, Maayan N, Soares-Weiser K, Donegan S, Garner P. Deworming drugs for soil-transmitted intestinal worms in children: effects on nutritional indicators, haemoglobin, and school performance. *Cochrane Database Syst Rev* [Internet]. 2015 [cited 2018 Dec 16];(7). Available from: <https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD000371.pub6/abstract>
62. Awasthi S, Peto R, Read S, Richards SM, Pande V, Bundy D, et al. Population deworming every 6 months with albendazole in 1 million pre-school children in north India: DEVTA, a cluster-randomised trial. *The Lancet*. 2013;381(9876):1478–86.
63. John D, Issac A. Do mass deworming efforts improve the developmental health and well-being of children in low-and middle-income countries? Summary of the evidence and implications for public health programmes. *Clin Epidemiol Glob Health*. 2018;6(4):220–4.
64. Chandrasekhar S, Aguayo VM, Krishna V, Nair R. Household food insecurity and children's dietary diversity and nutrition in India. Evidence from the comprehensive nutrition survey in Maharashtra. *Matern Child Nutr*. 2017;13(S2):e12447.
65. Mutisya M, Kandala N, Ngware MW, Kabiru CW. Household food (in)security and nutritional status of urban poor children aged 6 to 23 months in Kenya. *BMC Public Health*. 2015;15(1):1052.
66. Schmeer KK, Piperata BA. Household food insecurity and child health. *Matern Child Nutr*. 2017;13(2):e12301.
67. Akombi BJ, Agho KE, Hall JJ, Wali N, Renzaho AMN, Merom D. Stunting, Wasting and Underweight in Sub-Saharan Africa: A Systematic Review. *Int J Environ Res Public Health*. 2017 Aug;14(8):863.
68. Alemayehu M, Tinsae F, Hailelassie K, Seid O, Gebregziabher G, Yebyo H. Undernutrition status and associated factors in under-5 children, in Tigray, Northern Ethiopia. *Nutrition*. 2015;31(7):964–70.
69. Klasen S. Nutrition, health and mortality in sub-Saharan Africa: Is there a gender bias? *J Dev Stud*. 1996;32(6):913–32.
70. Svedberg P. Undernutrition in Sub-Saharan Africa: Is there a gender bias? *J Dev Stud*. 1990;26(3):469–86.
71. Diamond-Smith N, Bishai D. Evidence of Self-correction of Child Sex Ratios in India: A District-Level Analysis of Child Sex Ratios From 1981 to 2011. *Demography*. 2015;52(2):641–66.

72. Wells JC. Natural selection and sex differences in morbidity and mortality in early life. *J Theor Biol.* 2000;202(1):65–76.
73. Kim SH, Kim S. National Culture and Social Desirability Bias in Measuring Public Service Motivation. *Adm Soc.* 2016;48(4):444–76.

Figures



Figure 1

The research setting