Risk Factors for Undernutrition among Children in South Central Somalia

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Abstract: *Objectives*: Undernutrition is a global public health challenge, especially in countries that experience extreme climate conditions and armed conflict. In Somalia, undernutrition is chronic, often graded for emergency response. The purpose of this study was to provide evidence on immediate, proximate, and distal risk factors for undernutrition in the most affected region of Somalia.

Setting: Data for the study was from cross-sectional nutritional surveys implemented by the Somalia Food Security and Nutrition Analysis Unit. Sampling for the surveys followed a multistage cluster sampling methodology where in the first stage, 30 clusters were randomly assigned to villages, and then 30 households were randomly selected from each cluster. Generalized Estimation Equations were used to determine risk factors for undernutrition. Data analysis followed survey analysis procedures.

Participants: 60,856 children aged 6-59 months from cross-sectional nutritional surveys implemented in South-Central Somalia from 2007 to 2012.

Results: When factors at the individual, household, and society level were considered simultaneously, diarrhea diseases and geographical region were the main risk factors for underweight, child gender, meal frequency, and livelihood zone were risk factors for stunting, while diarrhea and livelihood zone were the risk factors for wasting. Geographical region and livelihood system were significant factors for undernutrition.

Conclusions: Interventions to address undernutrition in Somalia should be tailored to the region and livelihood zone while prioritizing innovative climate-smart food production and addressing childhood illnesses. The study findings provide evidence to inform nutrition policy and programs that could eliminate nutrition disparities and the burden of childhood undernutrition in Somalia and other countries with similar contexts.

Keywords: Risk factors, Underweight, Stunting, Wasting, Somalia.

INTRODUCTION

Undernutrition continues to be a public health challenge with negative impacts on child survival and development that continue into adulthood. This public health challenge is worse in countries that are faced with armed conflict and extreme climate conditions like Yemen, Chad, South Sudan, the Central African Republic, and Somalia. In Somalia, undernutrition continues to threaten the survival and development of children, with the population level of acute undernutrition often above the WHO-defined critical level of 15.0% [1]. The effects of undernutrition include morbidity and mortality in infancy [2-5], diminished cognitive development, poor school performance [6, 7] and adolescent behavior [8], stature, income and assets [9], obesity [10], and non-communicable diseases in adulthood [11]. Undernutrition presents in the form of stunting (short length/height for age), wasting (low weight for height), and underweight (low weight for age) [12]. Globally 22% (149.2 million children) of children under five in 2020 were stunted, while 6.7% (45.4 million) children were wasted [13].

Somalia is on a path of developing from a fragile to a stable state, but progress is compromised by continuing political and institutional vulnerability. Economic development is slow, with GDP per capita (current US$) only improving from $127 in 1990 just before the Somalia State collapsed to $350 in 2013 and $438 in 2020, [14]. The country experiences a complex combination of natural and man-made disasters that keep it in a state of humanitarian emergency [15]. Armed conflict, especially in South Central Somalia (SCS), exasperates the impact of economic crises, poverty, and natural disasters like drought and flooding. Combination of extreme humanitarian factors precipitated the 1991-1992 famine that led to deaths as high as 74.0% of children under the age of five in some areas of SCS [16] and later the 2011-2012 famine in which 133,000 children under the age of five died [17]. Severe drought in 2016 pushed the country to the edge of another severe food crisis, and until 2019 populations were still struggling to recover from the effect of that drought. The effect of some improvements in rainfall, crop, and animal

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This article was produced as part of a Ph.D. while working in Somalia, before joining WHO.

production in 2019 was set back by desert locust infestation, flooding, and socioeconomic impacts of COVID-19 through 2020. In September 2021, the Food Security and Nutrition Analysis Unit for Somalia (FSNAU) and Famine Early Warning Systems Network (FEWS NET) warned that 1.2 million children under the age of five could be acutely malnourished, including nearly 213,400 who are likely to be severely malnourished [18].

The UNICEF conceptual framework of determinants of undernutrition asserts that undernutrition is caused by immediate factors that are influenced by underlying factors in the household which in turn are influenced by basic factors at the society level. Much as there is vast evidence that supports the conceptual framework of determinants of undernutrition, applying this framework in different contexts may reveal the role that different factors play leading to evidence-informed decisions for respective contexts. In Somalia, the influence of disease, household size, access to food, and vegetation on undernutrition have been examined [19]. However, to our knowledge, no other study has examined the influence of other important factors such as child feeding practice, access to safe water, and access to sanitation. Therefore, this study aimed to ascertain the immediate, proximate, and distal risk factors for undernutrition in SCS, the region that bears the heaviest burden of undernutrition in Somalia.

METHODOLOGY

Conceptual Framework

The UNICEF conceptual framework of determinants of undernutrition [20] was followed in mapping risk factors for undernutrition in its three forms of underweight, stunting, and wasting. According to the framework, exposure to infections like diarrhea [21-23], malaria, Acute Respiratory Infection (ARI), Environmental Enteric Dysfunction (EED) [23, 24], and inadequate dietary intake [25, 26] in children are the immediate causes of undernutrition. However, proximal factors in the household such as inadequate access to food [27-29], poor maternal and child feeding practices like breastfeeding [30, 31], and poor health conditions, including lack of safe water and sanitation [25], influence the immediate causes of undernutrition. The proximal factors are, in turn, influenced by distal factors that determine the quality and quantity of resources available in the household. Distal factors may include national income [32], conflict and violence [32-34], ethnicity [35], gender equality/inequality [36] regional characteristics like rural/urban location [37, 38] and education [39, 40]. Maternal characteristics such as age, nutritional status, and physical health have also been found to influence the nutritional status of children. Child age and gender are individual non-modifiable child characteristics that also influence undernutrition. In theory, all these factors should be considered in analyzing risk factors for undernutrition.

Data and Variables

This cross-sectional study was based on data collected by the Food Security and Nutrition Analysis Unit (FSNAU) of Somalia through nutrition surveys from 2007 to 2012. Surveys conducted over this period had consistent data on household variables required for this study. FSNAU followed the Standardized Monitoring and Assessment of Relief and Transitions (SMART) methodology in conducting biannual nutrition surveys; one after the long (April to June) rainy season and the other post the short (October to November) rainy season. SMART is a survey method that is used to standardize nutrition and mortality surveys in emergency contexts [41]. Participants in the nutrition surveys were children aged 6-59 months and mothers of the children or responsible caregivers, where mothers were absent. This study covers the regions of Galgadud, Hiran, Bakool, Gedo, Bay, Middle Shabelle, Lower Shabelle, Lower Juba, and Middle Juba as defined in the administrative map of SCS by the United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA).

Sampling for the primary nutrition surveys followed a multistage cluster sampling methodology wherein, in the first stage, 30 clusters were randomly assigned to villages. Then 30 households were randomly selected from each cluster for the survey. Probability proportional to the population size method was used in assigning clusters based on a list of villages and the population in each village [42, 43]. Dependent variables were stunting (HAZ < -2), wasting (WHZ <-2), and underweight (WAZ < -2) as measures of undernutrition based on the WHO Child Growth Standards [44]. The variables were computed using anthropometric data from the nutrition surveys and analyzed separately. The conceptual framework of determinants of undernutrition was the basis for identifying independent variables for this study, as shown in Figure **1**. The final set of variables was based on the availability and completeness of the data. Malaria, Diarrhea, ARI two weeks prior to the survey and suspected Measles four weeks prior to the survey were the measures for

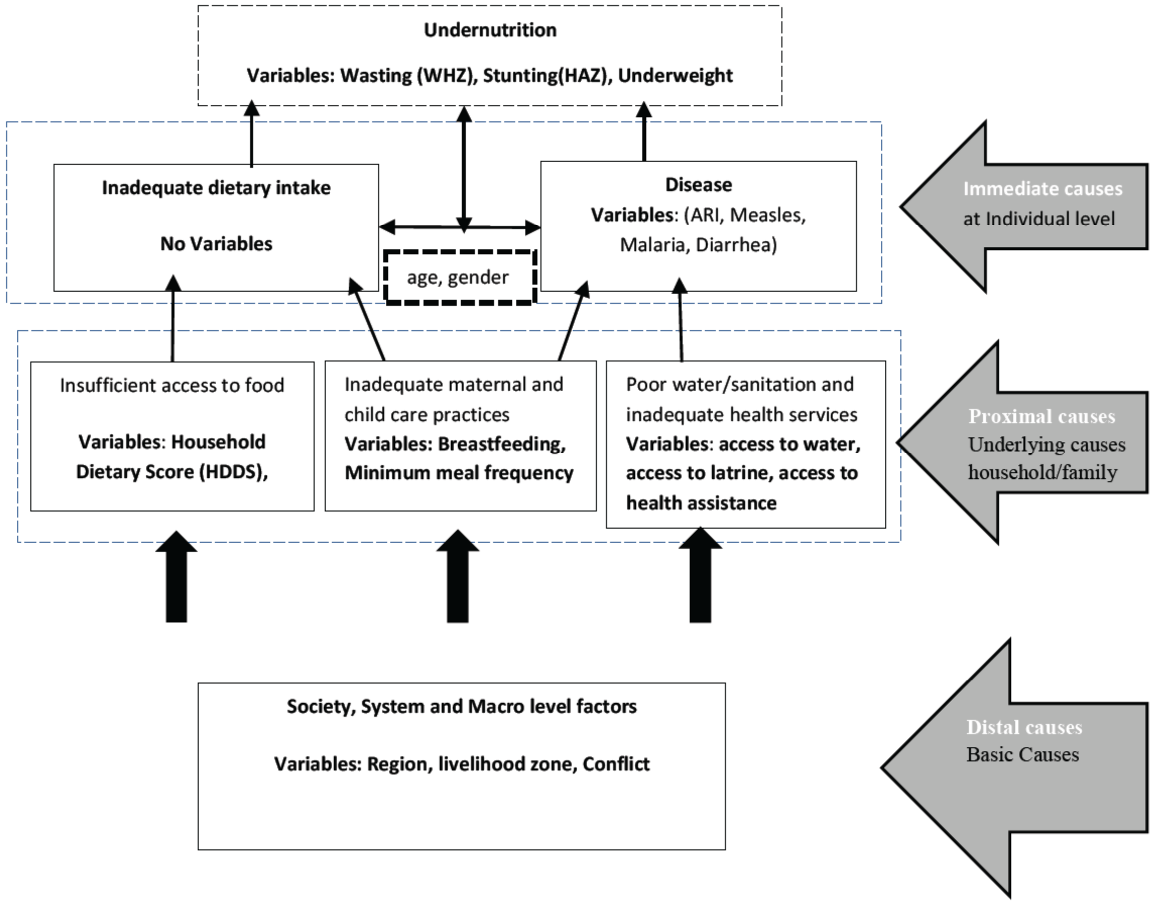

Figure 1: Schematic diagram of study variables; adapted from UNICEF [73].

disease as immediate risk factors for undernutrition. Data on Child diet diversity that could have been used as a proxy for dietary intake as an immediate factor was not consistently available, and therefore, it was not examined.

The proximate factors examined were access to food, care, feeding practices, household health environment, and health assistance. Access to food was measured by Household Diet Diversity Score (HDDS), care, and feeding was measured by exclusive breastfeeding and minimum meal frequency. At the same time, the health environment was examined by access to safe water and access to sanitation facilities. Access to health assistance was measured by the assistance sought in child illness. Age of the child, gender of the child, age of the mother, gender of the household head, year, and season were tested as covariates or confounding variables and controlled accordingly. Geographic region, livelihood system (Pastoral, Agro-pastoral, Riverine, Internally Displaced Persons (IDP), and conflict were examined as distal factors that could be associated with undernutrition. The conflict was measured by the count of incidences of armed conflict as provided by the Armed Conflict Location and Event Data [45].

Ethical Approval

The Ministry of Health Somalia provided ethical approval for this study. Individuals in all participating households provided informal verbal consent during the collection of the raw data that was used in this secondary analysis.

Data Analysis

Data analysis started with merging nutrition surveys data in each livelihood zone within the SCS area into a single dataset. Statistical modeling was conducted using Generalized Estimation Equations (GEE) because of correlations between observations and repeated measures of household-level variables for children in the same household. GEE was also suitable for generating population-level estimates while considering correlations between observations [46, 47]. GEE uses weighted combinations of observations in a cluster, enabling it to generate more efficient regression parameters, more accurate standard errors, and confidence intervals when compared to other methods for analyzing correlated data [47]. Following the UNICEF's conceptual framework, bivariate analysis and multivariate analysis (model 1) were performed at each level. Factors that were significant at each level (p<0.05) were then included in a final mixed-effects model (model 2) to consider all the levels of exposure simultaneously. All models were adjusted for the year. Survey analysis procedures were followed using strata sampling sample weights generated from population estimates. All Data analysis was performed using Stata version 13.1 (Stata Corp, College Station, TX).

Public Involvement

Members of the public were not involved in setting the research question, the design, or the implementation of the research. However, members of the Somalia nutrition working group and other nutrition practitioners in Somalia advised on the research questions, access and management of data, and dissemination of the results.

RESULTS

A total of 87,731 children aged 6-59 months in SCS participated in 12 surveys from 2007 to 2012. Of the total, 3,612 children that did not have complete anthropometric data, 8,363 children that had statistically implausible values, and 14,900 children from households that could not be uniquely identified for the GEE analysis were excluded. We considered implausible values to be ±3 Z-scores from the mean HAZ, WAZ, WHZ for each seasonal survey in each of the six years based on the SMART methodology applied in the primary surveys [41]. The final dataset had 60,856 children. Data on predictor variables had missing data; however, missing data analysis revealed that the difference between samples with complete data and samples with missing data were not statistically and that data were missing at random. The household-level intracluster correlation coefficient (ICC) for underweight, stunting and wasting was 0.033 (95% CI: 0.027, 0.039), 0.023 (95% CI: 018, 0.029) and 0.027 (95% CI: 0.021, 0.024) respectively with region and livelihood zone controlled.

Table **1** shows an overview of the variables and their distribution. The majority of the children were more than 24 months old. Male children were 35%, while male-headed households were 87%. The prevalence of underweight, stunting and wasting was 15%, 18%, and 11 %, respectively. Measles infection within four weeks preceding participation in a survey was only reported in 4% of children, while diarrhea, ARI, and malaria within two weeks preceding participation in a survey was reported in 13%, 45%, and 20%, respectively. respectively. Only 3% of the children were exclusively breastfed, while 42% received meals the minimum number of times required for their age. Sixty-eight lived in households with access to safe water, while 66% had access to sanitation facilities. Health assistance for childhood illnesses was sought from a health facility for only 20%; the majority sought care from traditional healers or prayers. The majority of the children were from the Gedo region, while the majority lived in agro-pastoralist households.

Risk Factors for Underweight, Stunting, and Wasting

Underweight

Among the immediate risk factors, diarrhea (AOR = 1.44, 95% CI [1.32, 1.57]; p <0.001), and malaria (AOR = 1.12, 95% CI [1.03, 1.22]; p <0.01) were significantly associated underweight. Among the proximate factors HDDS (AOR = 0.96, CI [0.93, 0.99]; p <0.05) was significantly associated with underweight (Table **2**). Among distal factors, both region and livelihood were significantly associated with underweight, showing that children in Hiran (AOR = 0.66, [1.48, 0.92] p <0.01) and Galgadud (AOR = 0.29, [0.09, 0.94] p <0.05) regions were less likely to be underweight compared to children Banadir. Children in agro-pastoral populations (AOR = 1.26, CI [1.09, 1.47]; p <0.01) had significantly higher risk of being underweight. The single combined model (model 2) of significant factors at the individual, household, and society level showed that diarrhea and region remained significant risk factors for underweight. Diarrhea increased the odds of being underweight by 63% (AOR = 1.63, CI [1.40, 1.89]; p <0.001) while the odds of underweight reduced in Hiran, Middle Shabelle, Lower Juba, and Middle Juba. Malaria, household diet diversity, and livelihood lost significance when factors at all levels were considered simultaneously.

Stunting

Stunting was significantly associated with diarrhea (AOR = 1.12, 95% CI [1.03, 1.21]; p <0.01) and malaria (AOR = 1.15, 95% CI [1.06, 1.25]; p <0.01) among immediate risk factors (see Table **3**). Female children had a lower risk of being stunted compared to males (AOR = 1.78, 95% CI [0.73, 1.83]; p <0.001). Stunting was significantly associated with minimum meal frequency and household diversity at the proximate level. The odds of stunting among children that

Table 1: Overview of Variables and their Distribution in the Final Data set N= 60,856

Variables	n	Weighted %/ mean	Variables	n	Weighted % /mean
Outcome variables					
Underweight			Access to safe water		
Yes	13886	15	Unprotected	26444	32
No	46970	85	Protected	21288	68
Stunted			Assistance for child illness		
Yes	16304	18	No assistance sought	8623	14
No	44552	82	Own Medication	2591	1
Wasting			Traditional healer/Prayers	5554	60
Yes	9894	11	Private Clinic/Pharmacy	7543	12
No	50962	89	Public health Facility	4474	8
Immediate factors			Access to sanitation		
Measles infection			Yes	19242	66
Yes	2145	4	No	25571	34
No	56134	96	Gender (head of household)		
Diarrhea			Male	31470	87
Yes	11159	13	Female	8381	13
No	49322	87	***Distal factors***		
ARI			Region		
Yes	12624	45	Bakool	3984	4
No	47866	55	Hiran	9643	8
Malaria			Galgaduud	5933	39
Yes	9312	20	M.Shabelle	6,335	7
No	37101	80	L.Juba	5,012	7
Age			M.Juba	5,238	6
=<24	21549	35	L.Shabelle	6,872	16
>24	39307	65	Gedo	13,487	5
Sex			Bay	3896	4
Male	30803	35	Banadir	639	5
Female	30053	65	Livelihood zone		
Proximal factors			Pastoral	16945	53
Household Diet Score		7	Agropastoral	22041	22
Exclusive breastfeeding			Riverine	14502	13
Yes	380	3	Urban	218	4
No	12203	97	IDP	4469	8
Min Meal Frequency			Conflict		8.3
Yes	5235	42	Season Gu	36662	72
No	7941	58	Dyer	24194	28

n – Number of subjects in the sample; IDP = Internally Displaced Persons.

Table 2: Models of Association between Immediate, Proximate, and Distal Risk Factors for Underweight in Children under the Age of 5 in South Central Somalia

	Bivariate			Model 1 (Multivariate)			Model 2 (all levels of exposures)		
Variables	**COR**	**P**	**95% CI**	**AOR**	**P**	**95% CI**	**AOR**	**P**	**95% CI**
Immediate factors									
Measles infection (Y)	1.94	0.128	0.83,4.53						
Diarrhea (Y)	2.83	<0.05*	1.26,6.40	1.44	<0.001*	1.32,1.57	1.63	<0.001*	1.40,1.89
ARI (Y)	0.31	0.117	0.07,1.35						
Malaria (Y)	1.17	<0.001*	1.08,1.27	1.12	<0.01*	1.03,1.22	0.98	0.786	0.83,1.15
Age (>24)	0.51		0.22,1.21						
Sex (F)	0.38	0.064	0.14,1.06						
Proximal factors									
Household Diet Score	0.72	0.019	0.54,0.95	0.96	<0.05*	0.93,0.99	0.96	0.054	0.92,1.00
Exclusive breastfeeding(Y)	0.67	0.057	0.44,1.01						
Min Meal Frequency (Y)	0.80	0.083	0.62,1.03						
Access to safe water (Y)	0.28	0.057	0.07,1.04						
Assistance for child illness (reference: No assistance)									
Own Medication	0.86	0.186	0.69,1.07						
Traditional healer/Prayers	0.12	0.014	0.02,0.65						
Private Clinic/Pharmacy	1.01	0.877	0.86,1.19						
Public health Facility	1.06	0.628	0.84,1.34						
Access to sanitation (Y)	0.23	<0.05*	0.06,0.91	0.92	0.306	0.78,1.08			
Mother's Age	1.08	0.075	0.99,1.17						
Gender of the hh head(F)	2.46	0.139	0.75,8.09						
Distal factors									
Region (reference: Banadir)									
Bakool	1.92	<0.001*	1.38,2.67	0.91	0.576	0.65,1.27	0.60	0.114	0.32,1.13
Hiran	1.37	0.069	0.98,1.93	0.66	0.014	0.48,0.92	0.58	0.011	0.38,0.88
Galgaduud	0.21	0.077	0.04,1.18	0.29	0.040	0.09,0.94	1.23	0.464	0.71,2.14
M.Shabelle	1.48	<0.05*	1.06,2.06	0.75	0.079	0.54,1.03	0.47	<0.01*	0.29,0.75
L.Juba	1.38	0.184	0.86,2.22	1.08	0.745	0.68,1.72	0.39	<0.001*	0.24,0.63
M.Juba	1.58	<0.05*	1.14,2.20	0.91	0.565	0.65,1.26	0.53	<0.05*	0.32,0.87
L.Shabelle	1.77	<0.01*	1.27,2.44	0.82	0.200	0.60,1.11	0.68	0.062	0.45,1.02
Gedo	1.79	<0.001*	1.30,2.46	1.03	0.863	0.75,1.40	0.99	0.975	0.60,1.65
Bay	2.19	<0.00*	1.58,3.05	0.71	0.075	0.49,1.03			
Livelihood zone (reference: Pastoral)									
Agropastoral	4.3	0.033	1.12,16.59	1.26	0.003	1.09,1.47	1.14	0.229	0.92,1.42
Riverine	4.1	<0.05*	1.06,15.68	1.04	0.646	0.87,1.26	1.15	0.348	0.86,1.52
Urban	1.4	0.667	0.32,5.87	0.87	0.699	0.44,1.75			
IDP	3.4	0.079	0.87,12.92	1.22	0.064	0.99,1.50	0.87	0.474	0.59,1.28
Conflict	1.0	0.173	1.00,1.01						

*All models adjusted for year. Min Meal Frequency = Minimum Meal Frequency. hh= household.

Table 3: Models of Association between Immediate, Proximate, and Distal Risk Factors for Stunting in Children under the Age of 5 in South Central Somalia

	Bivariate			Model 1 (Multivariate)			Model 2 (all levels of exposures)		
Variables	**OR**	**P**	**95% CI**	**AOR**	**P**	**95% CI**	**AOR**	**P**	**95% CI**
Immediate factors									
Measles infection (Y)	2.02	0.111	0.85,4.79						
Diarrhea (Y)	2.39	0.043	1.03,5.55	1.12	<0.01*	1.03,1.21	1.04	0.612	0.89,1.22
ARI (Y)	0.28	0.093	0.06,1.24						
Malaria (Y)	1.17	<0.001*	1.07,1.27	1.15	<0.01*	1.06,1.25	1.14	0.127	0.96,1.36
Age (>24)	1.00	0.623	0.99,1.01						
Sex (F)	0.34	<0.05	0.12,0.97	0.78	<0.001*	0.73,0.83	0.66	<0.001*	0.57,0.76
Proximal factors									
Household Diet Score	0.74	0.05	0.55,1.00	1.12	<0.001*	1.06,1.18			
Exclusive breastfeeding(Y)	0.71	0.082	0.49,1.04						
Min Meal Frequency (Y)	0.62	<0.001*	0.50,0.78	0.71	<0.01*	0.55,0.92	0.68	<0.001*	0.58,0.80
Access to safe water (Y)	0.29	0.074	0.08,1.13						
Assistance for child illness (reference: No assistance)									
Own Medication	0.99	0.897	0.79,1.23						
Traditional healer/Prayers	0.09	0.006	0.02,0.50						
Private Clinic/Pharmacy	1.05	0.514	0.91,1.22						
Public health Facility	1.22	0.064	0.99,1.50						
Access to sanitation (Y)	0.27	0.07	0.07,1.11						
Mother's Age	1.08	0.09	0.99,1.17						
Gender of the hh head(F)	2.51	0.143	0.73,8.62						
Distal factors									
Region (reference: Banadir)									
Bakool	1.26	0.121	0.94,1.69	2.35	0.261	0.53,10.42			
Hiran	0.94	0.72	0.69,1.29	1.69	0.475	0.40,7.12			
Galgaduud	0.12	<0.05*	0.02,0.64	0.70	0.664	0.14,3.54			
M.Shabelle	1.32	0.065	0.98,1.77	2.28	0.275	0.52,10.05			
L.Juba	1.13	0.553	0.75,1.72	3.72	0.101	0.78,17.87			
M.Juba	1.49	0.007	1.12,1.99	3.05	0.145	0.68,13.62			
L.Shabelle	1.95	<0.001*	1.47,2.59	2.77	0.164	0.66,11.57			
Gedo	1.14	0.372	0.86,1.50	2.63	0.205	0.59,11.67			
Bay	1.56	<0.01*	1.17,2.10	1.99	0.357	0.46,8.61			
Livelihood zone (reference: Pastoral)									
Agropastoral	5.33	<0.05*	1.40,20.26	1.41	0.000	1.20,1.66	1.702	<0.001*	1.39,2.08
Riverine	8.43	<0.01*	2.22,32.07	1.80	0.000	1.51,2.15	2.42	<0.01*	1.93,3.03
Urban	1.94	0.361	0.47,8.05	0.92	0.726	0.58,1.47	0.583	0.374	0.18,1.91
IDP	5.60	<0.05*	1.47,21.33	1.73	0.000	1.34,2.24	1.818	<0.001*	1.43,2.32
Conflict	1.00	<0.05*	1.00,1.0	1.00	0.185	1.00,1.01			

All models adjusted for a year. Min Meal Frequency = Minimum Meal Frequency. hh= household.

Table 4: Models of Association between Immediate, Proximate, and Distal Risk Factors for Wasting in Children under the Age of 5 in South Central Somalia

	Bivariate			Model 1 (Multivariate)			Model 2 (all levels of exposures)		
Variables	**OR**	**P**	**95% CI**	**AOR**	**P**	**95% CI**	**AOR**	**P**	**95% CI**
Immediate factors									
Measles infection (Y)	1.94	0.121	0.84,4.47						
Diarrhea (Y)	2.38	<0.05*	1.07,5.26	1.39	<0.001*	1.25,1.54	1.58	<0.001*	1.37,1.82
ARI (Y)	0.34	0.141	0.08,1.43						
Malaria (Y)	1.14	<0.05*	1.03,1.26	1.09	0.084	1.25,1.21			
Age (>24)	1.01	0.152	1.00,1.02						
Sex (F)	0.37	0.05	0.14,1.00						
Proximal factors									
Household Diet Score	0.70	<0.01*	0.53,0.92	1.03	0.161	0.99,1.07			
Exclusive breastfeeding(Y)	0.51	<0.01*	0.34,0.77	0.69	0.175	0.40,1.18			
Meal Frequency (Y)	0.96	0.744	0.73,1.26						
Access to safe water (Y)	0.29	0.057	0.08,1.04						
Assistance for child illness (reference: No assistance)									
Own Medication	0.83	0.161	0.64,1.08						
Traditional healer/Prayers	0.16	0.034	0.03,0.87						
Private Clinic/Pharmacy	1.08	0.434	0.89,1.31						
Public health Facility	1.02	0.828	0.82,1.28						
Access to sanitation (Y)	0.30	0.074	0.08,1.12						
Mother's Age	1.08	0.05	1.00,1.16						
Gender of the hh head(F)	2.23	0.171	0.71,6.99						
Distal factors									
Region (reference: Banadir)									
Bakool	2.21	<0.001*	1.46,3.37	1.37	0.156	0.89,2.10	1.39	0.137	0.90,2.14
Hiran	2.65	<0.001*	1.69,4.17	1.57	0.049	1.00,2.45	1.53	0.064	0.98,2.40
Galgaduud	0.37	0.258	0.07,2.06	0.42	0.179	0.12,1.49	0.44	0.192	0.13,1.51
M.Shabelle	2.03	<0.01*	1.34,3.09	1.43	0.096	0.94,2.19	1.44	0.093	0.94, 2.20
L.Juba	1.83	0.034	1.05,3.19	1.51	0.148	0.86,2.64	1.50	0.157	0.86, 2.61
M.Juba	1.92	<0.01*	1.27,2.92	1.49	0.071	0.97,2.29	1.26	0.291	0.82, 1.93
L.Shabelle	1.67	<0.05*	1.10,2.53	1.17	0.463	0.77,1.76	1.14	0.536	0.75, 1.72
Gedo	2.71	<0.001*	1.80,4.07	1.78	0.006	1.18,2.68	1.78	<0.01*	1.18, 2.69
Bay	2.59	<0.001*	1.70,3.95	1.24	0.366	0.78,1.99	1.25	0.356	0.78, 2.02
Livelihood (reference: Pastoral)									
Agropastoral	2.81	0.127	0.75,10.55	0.88	0.125	0.74,1.04	0.82	<0.05*	0.69,0.98
Riverine	1.95	0.324	0.52,7.34	0.59	<0.001*	0.48,0.72	0.58	<0.001*	0.47,0.72
Urban	1.09	0.906	0.26,4.58	0.90	0.771	0.46,1.79	0.92	0.806	0.46,1.83
IDP	2.00	0.308	0.53,7.56	0.93	0.489	0.75,1.15	0.90	0.32	0.72, 1.11
Conflict	1.00	0.843	1.00,1.01						

All models adjusted for a year. Min Meal Frequency = Minimum Meal Frequency. hh= household.

were given food a minimum number of times required for their daily consumption was reduced by 29% (AOR = 0.71, CI [0.55, 0.92]; p <0.01). Multiple regression of distal factors showed that the livelihood zone was significantly associated with stunting. Compared to pastoralists, the odds of stunting increased in all livelihoods except among the urban where the odds slightly reduced (AOR = 0.92, 95% CI [0.58, 1.47). Conflict was marginally associated with stunting (COR=1, 95% CI [1.00, 1.01) and lost significance in multivariate analysis. When all the levels of exposure were considered, only child gender, minimum meal frequency, and livelihood remained statistically significant risk factors for stunting. The odds of stunting were reduced by 34.0% (AOR = 0.66, CI [0.57, 0.76]; p <0.001) among female children and reduced by 32.0% (AOR = 0.68, CI [0.58, 0.80]; p <0.001) among children that received minimum frequency of feeding required for their age.

Wasting

Among immediate risk factors for undernutrition, diarrhea (AOR = 1.39, 95% CI [1.25, 1.54]; p <0.001) was significantly associated with wasting (Table **4**). Bivariate analysis showed that exclusive breastfeeding and HDDS reduced the odds of wasting by 49% (COR = 0.51, CI [0.34,0.77]; p <0.001) and 30% (COR = 0.70, CI [0.53, 0.92]; p <0.05 respectively. However, considered together in the multivariate analysis, they both lost significance in their association to wasting. A single model with all the levels of exposure considered simultaneously shows that diarrhea, region, and livelihood zone were significantly associated with wasting. Diarrhea increased the odds of wasting by 58% (AOR = 1.58, CI [1.37,1.82]; p<0.001). Region was associated with wasting. However, the association between region and wasting was only significant in Gedo, where the odds of wasting increased when compared to Banadir after controlling for other factors. The livelihood zone remained significantly associated with wasting. Compared to pastoralists, the odds of wasting reduced in agropastoral and riverine zones.

Overall, access to assistance for child illnesses did not show a significant association with underweight, stunting, or wasting.

DISCUSSION

Infections can instigate appetite loss, poor absorption of nutrients, and diverting nutrients to fight disease and repair the body tissue, which predisposes children to undernutrition. However, undernutrition increases vulnerability to diseases and infections, thus propagating the vicious cycle of malnutrition [48]. The study showed that diarrhea within the last two weeks increased the risk of being underweight, stunting, and wasting. These results are consistent with a study in Somalia [19] and several from elsewhere [22, 48-50]. Results also showed that malaria or fever increased the odds of being underweight and stunting. While the evidence on the direction of the causal relationship between malaria and undernutrition is mixed, some studies have demonstrated an increased risk of undernutrition among children with a higher prevalence of malaria [51, 52]. ARI was significantly associated with any of the three undernutrition conditions, contrary to findings from a similar study in Somalia [53]. The difference in the results could be related to the scope of the studies. This study did not find a significant association between measles infection and any of the three undernutrition outcomes similar to what has previously been established [19]. However, measles alone or in combination with other forms of undernutrition has been shown to increase child mortality [54, 55] and, therefore, a public health risk, especially in refugee camps, famine-affected, and displaced population populations. Diarrhea and malaria are preventable and treatable with low-cost interventions. Children can recover from diarrhea and recover development loss; however, increased diarrhea episodes could lead to stunting conditions [56]. Trusted community health influencers could be resourceful in promoting hygiene, use of safe water and sanitation, optimal breastfeeding, use of mosquito nets, and health care seeking. This study established that caregivers primarily sought health assistance from traditional healers or prayers.

Compared to males, females were less likely to be stunted or wasted. Other studies have found similar results [17, 47, 49]. The explanation of the association could be more biological than environmental as it is expected that gender-biased feeding behaviors in the household would likely favor boys over girls in the context of Somalia. Age was not significantly associated with any undernutrition conditions though evidence shows that the risk of stunting increases with age [49, 57].

Proximal Predictors of Undernutrition

Household diet diversity was associated with being underweight and wasting. Adding one food group to a household's diet reduced the likelihood of being underweight or wasting. However, the positive effect of household diet diversity diminished when other factors were considered. The significance of diverse diets has been documented in other studies [58-60]. Still, other studies have not found a positive association [61], arguing that factors beyond diet diversity have a role in driving undernutrition. The diminishing effect of household diet diversity in the multivariate analysis may suggest a marginal effect and the importance of other factors in the household. However, other literature suggests that children in food-insecure households are likely to have limited diet diversity and more likely to be stunted, underweight, or wasted [30, 58]. In 2011 more than 20.0% of the populations in SCS faced extreme food shortages surpassing the threshold for famine classification [62]. The food security situation in Somalia remained precarious over the period covered by this study which could explain the observed association between household diet diversity and underweight and wasting, albeit marginal.

Results of this study showed that exclusive breastfeeding was only significant in the bivariate analysis for wasting and lost significance in multivariate analysis. This finding is contrary to what was expected given the protective effect of exclusive breastfeeding on child undernutrition that has been reported by others [23, 63, 64]. However, the prevalence of wasting among exclusively breastfed children was 9.9% compared to 15.9% among children that were not exclusively breastfed with a significant association between exclusive breastfeeding and wasting, $\chi^2(1) = 7.549$, $p<0.001$. Further, stunting was 19.5% among exclusively breastfed children compared to 25.2% among children not exclusively breastfed, while underweight was also lower among exclusively breastfed children (16.4% vs. 21.9%). Both Stunting and underweight were significant associated with exclusive breastfeeding ($\chi^2(1) = 7.549$, $p<0.05$ and $\chi^2(1) = 10.243$, $p<0.05$. These results suggest the benefits of exclusive breastfeeding despite the weak evidence of its role as a risk factor for undernutrition in this study.

Food insecurity, as often seen in Somalia, directly affects caregivers' ability to optimally feed their children for protection against undernutrition. Minimum feeding frequency decreased the chances of children being stunted by 20 --42.0%, similar to what has been established in other studies [60, 65]. The frequency of feeding children in a household could be influenced by food availability and the caregiver's knowledge of feeding requirements for infants and young children.

Water, Sanitation, and Hygiene play a critical role in the nutritional status of children through three pathways to undernutrition: diarrhea/diarrheal diseases, intestinal parasite infections, and environmental enteropathy, especially among children [66]. This study showed that neither access to safe water nor sanitation facilities was a significant risk factor for undernutrition conditions when other household-level factors were considered. However, access to sanitation facilities showed a significant association with underweight in bivariate analysis. These results were unexpected and contrary to other studies documenting an increased risk of undernutrition due to poor water and sanitation access [67, 68]. However, these results may suggest that access to safe water and sanitation are not enough to protect children from undernutrition. They may point to other factors like hygiene practices and water handling in the household that may predispose children to diarrheal diseases and intestinal infections. The absence of a significant association between safe water and sanitation access with undernutrition, yet a significant association was observed between diarrhea and undernutrition conditions, may suggest a mediation effect of hygiene that should be explored. Investing in hygiene behavior change interventions could increase the impact of access to safe water and sanitation in reducing undernutrition among children.

Access to health assistance was not found to be a significant risk factor for underweight, stunting, or wasting. However, some advantages were observed between different options of health care when compared to not having any health care at all. It appears that these advantages were not strong enough to support an association between access to health care and undernutrition.

Distal Predictors of Undernutrition

South Central Somalia is divided into 10 administrative regions that have variations in economic status, governance and political dynamics, climate, livelihood systems, and the urban vs. rural population distribution that may variably influence the nutritional status of children.

This study shows that geographical region was a significant predictor of underweight and wasting. When compared to Banadir, the region that hosts the government capital and offers better social services, children in all the regions except Galgadud were more likely to be underweight or wasted. When all levels of exposure were considered, the odds of wasting in all the regions were higher than Banadir especially Gedo, Hiran, and L. Juba though the association was not significant. The higher odds of wasting could be linked to the heightened level of food insecurity and conflict that were prevalent over the period covered by this study. Drought and armed conflict severely constrained food production and access to markets and basic services. It is argued that drought conditions exacerbated the effects of the already existing fundamental clan-based social and political disadvantages in the most affected populations [69]. The association between geographical region or area of residence with undernutrition has been found in other studies [60, 70]. This study shows that the association between region and child undernutrition is displayed in subnational disparities that call for targeted interventions to address immediate and underlying factors that influence the conditions in which children are born and raised.

Overall, study results showed higher chances of child undernutrition among agropastoral and riverine populations, which could be explained by Somalia's social, economic, and political position. Both agropastoral and riverine populations practice rain-fed agriculture, keeping some of the livestock with the poorer groups laboring in farms or urban areas to access food or income. Socially, they consist of minority clans that suffer dominance from larger clans and face forced displacements that leave them poorer and dependent on aid [69]. Drought, conflict, and other social-political factors that disrupt the livelihood of agropastoral and riverine populations propagate food insecurity in Somalia because they provide Somalia's food basket. The macro effect is increased undernutrition, especially among children and women. As such, overcoming social and political marginalization of the populations in the agropastoral and riverine areas of SCS to harness their food production capability could reduce vulnerability to food insecurity, redistribute wealth and tackle disparities in child nutrition and other human development indicators.

Armed conflict limits the ability of households to produce and or access food; it limits access to basic services, including health, and causes displacement that may interrupt infant and young child feeding practices [71]. These limitations and disruptions undermine children's nutritional status and may increase mortality and morbidity. However, the study results showed that conflict was not significantly associated with any of the undernutrition outcomes, contrary to what was expected and what has been previously established [34]. The possible explanation for this inconsistency could be the difference in the computation of the variable used in this study. While conflict did not directly affect underweight, stunting, or wasting, it was found to be significantly associated with access exclusive breastfeeding $\chi^2(1) = 11.3$, $p < 0.05$. Indeed a similar study on the effect of conflict practices in Ukraine found that mothers that discontinued breastfeeding before six months listed stress related to conflict as their primary reason for discontinuation [72].

Strengths and Limitations

To our knowledge, this is the first study to simultaneously examine the effect of immediate, proximate, and distal factors on undernutrition among under-five children in Somalia. The data used in this study is historical. Still, improvements in the status of the people and, therefore, the factors considered in this study could be minimal given the marginal change in GDP to date. The main strength of this study was the use of an extensive database from cross-sectional studies conducted over six years. However, data was not complete for all the observations, but an analysis of missing data revealed that the difference between observations with complete and those without complete data on the variables of interest was not significant. In the absence of cluster sampling information for all the original surveys, sample weights for survey analysis were only estimated at region and livelihood levels.

CONCLUSIONS

This research demonstrated that when all levels of exposure are considered, diarrhea diseases and geographical regions are the main risk factors for underweight. The main risk factors for stunting were child gender, meal frequency, and livelihood system, while diarrhea, region, and livelihood zone were the risk factors for wasting. The research also demonstrated significant immediate, proximate and distal risk factors that should inform nutrition programs focusing on different levels and subpopulations. Implementing strategies such as,

- Integrated Community Case Management (iCCM) at a national level to address diarrhea and malaria;
- addressing social and political marginalization while implementing climate-smart agricultural interventions in the agropastoral and riverine areas;

- promotion of contextually proven strategies for increasing uptake of infant and young child feeding practices;
- continued focus on hygiene behavior change,

These strategies could contribute to reducing child undernutrition and meeting SGD goals.

Similar actions could be appropriate in countries that experience similar drivers of undernutrition. Further research using more recent data could enhance the findings of this study.

ACKNOWLEDGEMENTS

The authors acknowledge FSNAU for providing the data used for this study. The authors specifically thank Daniel Molla, Abukar Nur, and George Thuo of FSNAU for their support in accessing and organizing the data.

AUTHOR CONTRIBUTIONS

MZ was responsible for the conception and design of the study, data acquisition, analysis, and interpretation of the results. HT and JR provided scientific oversight for the study and reviewed the manuscript.

COMPETING INTERESTS

None.

FUNDING

This research received no specific grant from any funding agency in public, commercial or not-for-profit sectors.

A DATA SHARING STATEMENT

The dataset is available from MZ, but access to it is subject to the consent of the Food Security and Nutrition Analysis Unit for Somalia.

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Received on 04-11-2021 Accepted on 04-02-2022 Published on 11-03-2022

https://doi.org/10.6000/1929-4247.2022.11.01.2