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Seasonal Variation of Household Food Insecurity and Household Dietary Diversity on Wasting and Stunting among Young Children in A Drought Prone Area in South Ethiopia: A Cohort Study

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ABSTRACT

This study was conducted to evaluate seasonal patterns of household food insecurity, dietary diversity, and household characteristics on wasting and stunting among children in households followed for 1 year in the drought-prone areas of Sidama, Ethiopia. A cohort study design was employed. Data were collected on the pre-harvest season (March and June) and post-harvest season (September and December) of 2017. We studied 935 children aged 6 to 47 months. At four seasons over a year, we had 3,449 observations from 897 households and 82% (2,816) (95% CI: 80.3–82.9) were food in-secured households. Severe food insecurity was higher in the pre-harvest (March; food scarcity season) which was 69% as compared to 50% of September ($P < .001$). From 3,488 observations, 44% (1,533) (95% CI: 42.3–45.6) of children were stunted. Stunting showed seasonal variations with 38% (95% CI: 34.7–41.0) in March and 49% (95% CI: 45.8–52.5) in December. Six percent (95% CI: 5.0–6.6) of children were wasted, with higher prevalence in March (8%) as compared to 3% of September ($P < .001$). Moreover, household characteristics such as poverty level, education, occupation and the household food insecurity and dietary diversity were associated with subsequent wasting and stunting.

Introduction

Globally, about 800 million people are food unsecured and 2 billion people experience micronutrient deficiencies (Pérez-Escamilla 2017). Food insecurity is a public health problem, especially in the African Sahel and in the lowlands in Ethiopia which has often been affected by drought and famines (Graves et al. 2019; Lindtjørn 1990; Regassa and Stoecker 2012). Food insecurity emerges as a predictor of child wasting and stunting. Although governments and international organizations developed nutrition policies and use

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interventional programs to reduce the burden of malnutrition (Tumilowicz et al. 2018), one possible reason why they did not achieve the target was that previous interventions did not sufficiently address the local contexts (Tumilowicz et al. 2018).

Although Ethiopia remains among the 20 poorest countries in the world (UNDP 2019), there has during the last 20 years been a rapid economic growth with increased per capita gross domestic product (GDP) with reductions in rates of poverty and stunting (Golan et al. 2019). According to four consecutive demographic and health surveys, the prevalence of stunting was 52% in 2000 (CSA 2001), 47% in 2005 (CSA 2006), 44% in 2011 (CSA 2012), and 38% in 2016 (CSA 2016). This shows that stunting has fallen by 2.5% per year. However, stunting still remains high, especially in rural areas and among the poorest (Golan et al. 2019). The prevalence of wasting has remained fairly constant and high at about 10% from 2000 to 2016, according to several Ethiopian Demographic Health Surveys (CSA 2001, 2006, 2012, 2016)

There are multiple risk factors of stunting according to the WHO conceptual framework (Beal et al. 2018). Previously conducted cross-sectional studies in Ethiopia revealed that there are numerous factors responsible for child wasting and stunting. These can broadly be classified into basic factors like child characteristics (Woldeamanuel and Tesfaye 2019), parental characteristics (Kahssay et al. 2020), and household characteristics (Woldeamanuel and Tesfaye 2019). Moreover, underlying factors like food insecurity (Mulu and Mengistie 2017) and sanitation (Girma et al. 2019; Kahssay et al. 2020; Woldeamanuel and Tesfaye 2019) and immediate factors such as inadequate dietary intake (Girma et al. 2019) and infections (Mulu and Mengistie 2017; Woldeamanuel and Tesfaye 2019) were associated with child wasting and stunting. However, there is a lack of information about risk factors of child wasting and stunting evaluated through cohort study in drought-prone areas of Sidama.

Ethiopia is committed to reducing child malnutrition by improving food availability, access, and consumption of nutritious food (Governement of the Federal Democratic Republic of Ethiopia 2016a), and adopted the "Seqota Declaration of 2015" with its ambitious goal of ending child malnutrition by the year 2030 (Governement of the Federal Democratic Republic of Ethiopia 2016b).

Malnutrition rates are highly sensitive to agricultural practice (Ruel and Alderman 2013) which is the main economic source of income for rural Ethiopian communities (Dadi 2013). Ethiopian farmers practice subsistence farming, which depends on rainfall (Abreha 2007), and in such communities, inadequate rain often leads to food shortages. If severe, such shortages lead to famines (Dadi 2013).

Boricha in Sidama in southern Ethiopia, where this study was conducted, has repeatedly been affected by famines. It is an area with high population growth (Tesfaye 2011), a chronically food-insecure area, and a large part of the population are supported by the Productive Safety Net Program (PSNP) (Tesfaye 2011). An earlier study from Boricha has shown that about 80% of households were food in-secured (Regassa and Stoecker 2012), and in 2017, about 12,100 households received such support (Boricha Woreda Agricultural Office Report 2017). Even in years with good rains, many households do not produce enough food for the whole year (Tesfaye 2011)

Most of the earlier studies conducted in Ethiopia were cross-sectional, and thus do not tell about the time relationship between food security, food availability and diversity, and the subsequent development of acute and chronic malnutrition. Some studies show that there are differences in wasting prevalence rates between the dry and wet seasons (Kinyoki et al. 2016) and between post-harvest and pre-harvest seasons (Roba et al. 2016). Earlier research from Sidama, where the current study was done showed seasonal wasting where nutrient-poor enset *(Ensete ventricosum)* is the major staple crop (Abebe et al. 2006; Bosha et al. 2019; Ferro-Luzzi et al. 2001). These studies were from the more fertile area of Sidama than the current study which was carried out in a drought-prone population, and also showed that children and adults both suffered from exposure to seasonal energy stress. Changes in weight-for-height Z-score were greater in individuals of low socioeconomic status (Branca et al. 1993).

Ethiopia requires effective community-based nutrition interventions with a multi-disciplinary approach to curb childhood malnutrition (Egata, Berhane, and Worku 2013). Implementation of community nutrition programs may require improved understanding of the local context and seasonality between the food diversity, rainfall pattern, occurrence of food security, wasting and stunting. Moreover, determining risk factors of child-undernutrition through cohort study would give stronger evidence about childhood wasting and stunting. Such information is not only important for policymakers at the national and regional levels but also for the practitioners of local public health and nutrition in the communities.

To our knowledge, few studies have evaluated the time relationship between exposure variables such as household characteristics, food insecurity, food diversity, on outcomes such as wasting (acute malnutrition) and stunting (chronic malnutrition) in different seasons of the year in Ethiopia. Such an understanding is important for public health and nutrition when implementing community-based nutrition interventions. Hence, the aim of this paper is to evaluate seasonal patterns of household food insecurity, dietary diversity, and household characteristics on wasting and stunting among children in households followed for 1 year in the drought-prone areas of Sidama, Ethiopia.

Methods and materials

Study design, period, and setting

We used a cohort study design to conduct a community-based follow-up study. We visited each selected household repeatedly over the course of 1 year to assess the risks of child wasting and stunting in different seasons.

Boricha is located in the Sidama Zone in the Southern Nation Nationalities and the Regional State of Ethiopia. It covers about 588 square km, and it is about 330 km from the capital city of Ethiopia. Located at 6º 46′N and 38º 04′E to 7º 01′N and 38º 24′E, its altitude is 1200–1800 mm above sea level. Most of its 315,000 people, 14% of whom are children aged 6–59 months, belong to the Sidama ethnic group and speak Sidamu Afoo. Most (95%) of the population live in rural areas, and most (95%) are subsistence farmers, though a few (4.5%) are merchants. The average family has five members, and the population density is 409 persons per square kilometer (Tesfaye 2011).

Boricha's subsistence agriculture system comprises mostly small, rain-fed farms that produce maize, enset (*Enset ventricosum*), potatoes, haricot beans, sweet potatoes, and teff. Some farmers grow cash crops like coffee, chat, spices, and eucalyptus. Livestock provide transport, milk, meat, and eggs, which are important income sources, though yield is typically low.

High population growth, absence of adequate surface water for irrigation, inaccessibility of underground water, decreasing soil fertility, low rainfalls, land degradation, and deforestation are important contributors to food insecurity in the area (Tesfaye 2011). Figure 1 shows a map of the Boricha district.
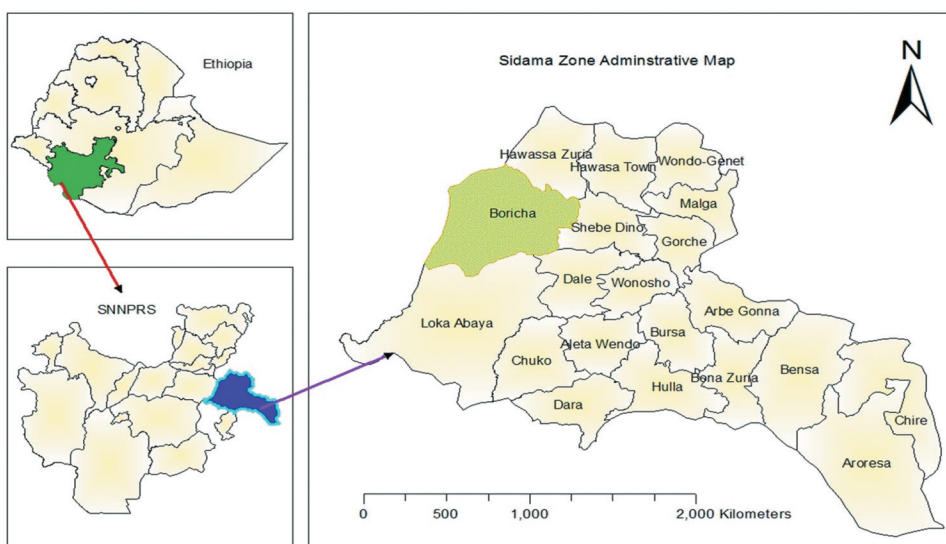

Figure 1. Boricha district map, Sidama, Southern Ethiopia, Ethiopia, 2017.

The rainy seasons in Sidama are biannual, and the *Belg* rains which last from March to Maycontribute to most of the crop production. The *Keremt* rains usually last from June to September and are smaller (Dadi 2013). Thus, following the agricultural cycle, the season of plenty usually occurs after the *Belg* harvest (mid-June to August) and Keremt harvest (October to November).

Outcome and exposure variables

We used the WHO conceptual framework (Beal et al. 2018) and analyzed our cohort study data using possible exposures of child malnutrition such as household characteristics, food access, food utilization, and seasonal variations of food security on our main outcome variables stunting and wasting.

The main outcomes of the study were the prevalence of stunting and wasting among children aged less than 5 years. The main exposure variables were season, wealth, household food insecurity access, household dietary diversity, child morbidity in the past 2 weeks, mother's marital status, family size, maternal age, maternal education, maternal occupation, child sex, child age in month, paternal education, paternal occupation, child's place of birth order, and if the child had been exclusively breastfed. Parental occupation was registered as the main economic activity of mothers and fathers, and could be housewife, daily laborer, government worker, farmer or merchant. In rural areas, for example, a father who works as a daily laborer could have farmland. A merchant husband usually has agriculture in addition to his business and his land size could even be large than that of an ordinary farmer. This may indirectly inform about different income-generating activities in addition to agricultural production. Even government workers have agricultural land in the rural part of Ethiopia. Therefore, we believe that occupation is an indicator of main income-generating activities of the household.

Study population and sampling

A two-stage sampling technique was employed. First, nine rural kebeles were randomly selected from the 39 rural kebeles (smallest administrative unit) in Boricha. Secondly, a cluster sampling technique was used to choose households from each sub-kebele's ("*gouts*") of the selected kebeles. Households with mothers who had children aged 6–47 months were included. The final sample included 897 households with 935 children, and all eligible children were included in our study. Respondents at interviews were biological mothers unless they had died or were divorced.

The sample size was calculated using OpenEpi 303 software (Dean, Sullivan, and Soe 2013). The sample size was estimated based on the following assumption: 95% level of confidence, 80% power, proportion of wasting in the lowland

region of Ethiopia at the post-harvest season 12.6%, proportion of wasting in the lowland region of Ethiopia at the pre-harvest season 6.6% (Roba et al. 2016)., and 15% non-response rate yielding a total of 872. However, we collected data from a total of 935 children. Figure 2 provides a detailed description of the study population.

Data collection procedures

Pretested and structured questionnaires were used to gather information about the household conditions, child health and nutrition characteristics, household dietary diversity, and household food security.

The data collectors had completed grades 10, 11, or 12, and were fluent speakers of the local *Sidamu Afoo* language and were familiar with the local area. The 18 data collectors and three supervisors were trained outside of the selected kebeles to conduct pretests using a structured questionnaire. Data collectors were assigned in pairs to maintain the quality of data collection. The questionnaire was prepared in English and then translated to *Sidamu Afoo* by the principal investigator (MB) and scrutinized by an experienced translator.

We used four season categories for data collection, based on the area's agricultural cycle: *Tsedey* (September, October, and November), *Bega* (December, January, and February), *Belg* (March, April, and May), and *Keremt* (June, July, and August). Data were collected in 2017 at the end of each seasonal month and beginning of each new season; that is, in December, March, June, and September. The questionnaires were checked for completeness, and households with incomplete questionnaires were re-visited, and all mistakes were corrected.
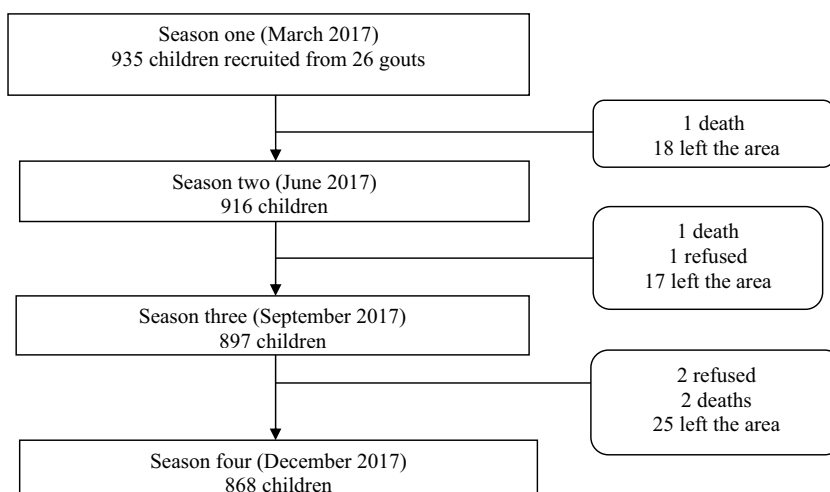

Figure 2. Study profile of children, Boricha district, Sidama, South Ethiopia, March through December 2017.

Child morbidity

Childhood diarrhea was defined as the passage of loose or liquid stools more frequently (three or more times per day) within 2 weeks period preceding to survey (WHO 2005). Fever was defined as an abnormally high body temperature assessed by asking mothers "Does the child's body feel hot" and cough was assessed by asking mothers "Did the child have cough in the 2 weeks„ preceding survey period (WHO 2005). The alternative response for the occurrence of diarrhea, fever, and cough was categorized as "Yes" or "No". Thus, child morbidity was the occurrence of diarrhea or cough or a fever in the 2 weeks preceding the data collection.

Food insecurity

Food security status was assessed using nine occurrence items and nine frequency questions of the Household Food Insecurity Access Scale (HFIAS), validated for Ethiopia, including measurements at different seasons (Coates, Swindale, and Bilinsky 2007; Hagos et al. 2015; Kabalo et al. 2019). The nine occurrence items were as follows: 1. worry about food, 2. unable to eat preferred food, 3. eat just a few kinds of food, 4. eat foods they really did not want to eat, 5. eat a smaller meal, 6. eat fewer meals in a day, 7. no food of any kind in the household, 8. go to sleep hungry, and 9. go a whole day and night without eating. The three major domains included anxiety and uncertainty about household food, insufficient quality, and insufficient food intake (Coates, Swindale, and Bilinsky 2007). The nine frequency follow-up questions measured the occurrence of the event in the previous 4 weeks. Food insecurity was classified as secure, mild, moderate, and severe, based on the HFIAS indicator guide version 3 (Coates, Swindale, and Bilinsky 2007). A food-secure household did not experience any or only rare food insecurity conditions, whereas severely food-insecure households often experienced insufficient food intake (Coates, Swindale, and Bilinsky 2007). Detailed information about the food insecurity classification is available in the HFIAS indicator guide (Coates, Swindale, and Bilinsky 2007).

Dietary diversity

Household Dietary Diversity Score of 24 hours recall measurements was utilized to measure household dietary diversity. A household dietary diversity used the past 24 hours recall for 12 food-groups and include cereals, roots or tubers, vegetables, fruits, meat or poultry, eggs, fish and seafood, pulses or legumes or nuts, milk and milk products, oil or fats, sugar or honey, and miscellaneous (Swindale and Bilinsky 2006).

Wealth index

Principal component analysis was used to construct the wealth index using household assets (Rutstein and Staveteig 2014). From the 28 initial variables, 11 were included in the analysis. Variables with 95% and above similar responses were dropped. Included were variables such as type and number of livestock (cow/oxen, chickens, goat, sheep, and horses); ownership of improved sanitation (latrine) facility; type of cooking fuel; housing condition (main construction of house wall, floor, and roof); number of sleeping rooms; ownership of chair; and ownership of a working mobile telephone. The principal component analysis revealed a Kaiser-Meyer-Olkin sampling adequacy of 0.67 and a significance level below 0.001. Finally, of the 11 components, four exceeded an initial eigenvalue of 1. Household wealth status was ranked based on percentile groups into five groups that had approximately the same number of cases: poorest, poor, medium, rich, and richest (Rutstein and Staveteig 2014).

Anthropometric measurements

Measurements were evaluated on children's weight, height, recorded age, and mid-upper arm circumference, using Emergency Nutrition Assessment for Standardized Monitoring and Assessment of Relief and Transitions software version 2011 (Erhardt, Golden, and Seaman 2011). Repeated evaluations were conducted until the coefficient of reliability reached 90% during the pretest. For children less than 24 months of age, height was measured in a recumbent position, using a length board, to the nearest 0.1 cm. Children older than 2 years were measured in the standing position to the nearest 0.1 cm. Weight was measured with light clothes and recorded to the nearest 100 g using a digital SECA scale (SECA GmbH, Germany). Child age was assessed using mothers' recall and using memorable events to aid in the recall.

Wasting and stunting were calculated based on the 2006 WHO Multi-center Growth Reference study cutoff values. Children whose weight-for-height Z (WHZ) scores were lower than −2 were classified as wasted, and children whose height-for-age Z (HAZ) scores were lower than −2 were categorized as stunted (WHO 2006).

Data analysis

Data were double entered using EpiData version 3.1 (Christiansen and Lauritsen 2010) and exported for further analysis to STATA version 15 (StataCorp, Texas, USA). The anthropometric data were analyzed using the

WHO Anthro version 3.2.2 (World Health Organization, Geneva, Switzerland).

The natural sequence of data presentation was done following the World Health Organization conceptual framework for childhood stunting (Beal et al. 2018). Thus, first, we analyzed the correlation between continuous background variables such as wealth, age of mother, education level on intermediary variables such as household food insecurity and household dietary diversity. After that, we analyzed how both the background variables and household food insecurity and household dietary diversity were associated with subsequent measures of wasting and stunting. For this, we both used correlation and multivariate analysis.

To analyze data collected over a period of 1 year on the same households, we used longitudinal, binary outcome, mixed-effect logistic regression statistical analysis to analyze wasting and stunting. Thus, the anthropometric measurement in one season was controlled for in the subsequent season. Household level was included to Kebele level (smallest administrative unit) hierarchy due to the presence of more than one child in one household for wasting and stunting outcome analyses. The model construction used Kebele level and household level for random effect equations and exchangeable variance-covariance structure of specifications for random effects. Time setting of the model used season as time variable and child code as a panel ID variable. Robust standard-error estimator and the main effect of independent variables were used. The model reports P-value, test statistics, fixed effects coefficients as odds ratio, and confidence interval with 95% confidence.

Bivariate analysis for all important independent variables was conducted, and associations with P-value less than 0.20 were considered for multivariate analysis to control for confounding. We have used Pearson's chi-squared test to compare categorical data. Maternal age, maternal education, and maternal occupation variables were considered for multivariate analysis of wasting and child age was considered for multivariate analysis of stunting even if P-value is greater than 0.20. The final model intra-class correlation coefficient for wasting was 8% at Kebele level and 28% at the household level. The final model intra-class correlation coefficient for stunting was 13% at the kebele level and 86% at the household level. We have utilized Akaike information criterion to compare models and we found the final models of wasting and stunting had smaller Akaike information criterion (AIC) that indicates for a better-fitting model. However, this model does not account for our few time-varying covariates as if this model has no clearly identified way of managing time-varying covariates.

Ethical consideration

The institutional review board at Hawassa University, College of Medicine and Health Sciences (Ref. No: IRB/001/09, Date: 13/09/2016) and the Regional

Committee for Medical and Health Research Ethics, Western Norway (ref: 2016/1631/REK Vest) approved this research proposal. Written permission was obtained from the Sidama Zone health department, Woreda administrators and selected health institutions. Informed written consent was obtained from all participating mothers or caregivers before interview. Mothers who were unable to sign used their thumb prints.

Results

Baseline characteristics

The study included 935 children (505 boys and 427 girls) from 897 households. More than 99% (892 of 897) of respondents were the biological mothers of the children. Among the households, 92% (809 of 897) of household heads were men. The family size ranged from 3 to 12 members, with a mean of 5. The age of mothers ranged from 18 to 46, with a mean age of 28 years. About 50% (448 of 897) of mothers were illiterate, and 98% (872of 897) were married. Most (83%; 727 households) were Protestant Christians, and 98% (876 of 897) of mothers belonged to the Sidama ethnic group. Most (87%; 773) mothers were housewives who also worked on their farms. More than half of husbands (561; 63%) were farmers, and 37% (332 of 897) were illiterate. Table 1 lists detailed background information.

The following analysis is based on correlation analysis of different variables (correlation matrix).

Households characteristics at baseline and subsequent HFI and FD

Table 2 indicates that poverty at baseline was associated with household food insecurity at all seasons. Similarly, mothers with low education had increased household food insecurity at all seasons. Richer households also had increased food diversity. Larger family size and also increasing maternal age were associated with higher household food insecurity and lower food diversity.

We also found that household characteristics such as wealth status, mother's education, child age, and maternal age were associated with stunting and wasting: Both lower education of the mother at the baseline and increasing child age were associated with increasing stunting at all seasons. Household food insecurity at the baseline was associated with increasing rates of wasting at all seasons. Similarly, food diversity at the baseline was also associated at all seasons for increasing stunting measurements. It also demonstrated that household food insecurity was associated with stunting and food diversity and further with wasting.

Thus, as described above, our univariate correlation analyses indicate that household characteristics were associated with household food insecurity and

Table 1. Baseline information about socioeconomic characteristics in Boricha district of Southern Ethiopia; March 2017.

Child Variables	March 2017 (n = 935)	
Child sex	Frequency	Percentage
Male	505	54.2%
Female	427	45.8%
Child age in months		
6–23 months	274	29.8%
24 month and above	645	70.2%
Household Variables	**March 2017 (n = 897)**	
Mother's age		
19 and below	2	0.2%
20–29	503	56.5%
30–39	361	40.6%
40 and above	24	2.7%
Mother's education		
Primary	402	45.1%
Secondary	42	4.7%
No formal education	448	50.2%
Mother's occupation		
Housewife & farmer	773	86.5%
Merchant/employed	98	11%
Other	23	2.6%
Father's education		
Primary	453	50.8%
Secondary and up	107	12%
No formal education	332	37.2%
Father's occupation		
Farmer	561	62.9%
Merchant/employed	237	26.6%
Other	94	10.5%
Family size		
5 and below	513	60.8%
Greater than 5	331	39.2%
Wealth status		
Poorest	179	20.1%
Poor	186	20.9%
Medium	169	18.9%
Rich	178	20%
Richest	180	20.2%
Religion		
Protestant	727	83.1%
Catholic	88	10.1%
Muslim	60	6.9%

dietary diversity, and household food insecurity and dietary diversity were associated with wasting and stunting of the children.

Household food insecurity

From 3,449 observations, 82% (2,816) reported being food insecure (95% CI: 80.3–82.9). Household food insecurity showed seasonal variations: the number of severely food-insecure households was higher in March (69%, 608 of 881) than in September (50%, 433 of 861) and December (38%, 320 of 835). Similarly, the number of severely food-insecure households was higher in June (76%, 666 of 871) than in September (50%, 433 of 861) and December (38%, 320 of 835). These findings indicate that the post-harvest seasons (September

Table 2. Correlation matrix of continuous variables to assess an association between baseline characteristics, household food insecurity, household dietary diversity, wasting, and stunting in four different seasons.

Variable	HFI 1	HFI 2	HFI 3	HFI 4	FD 1	FD 3	FD 4	WHZ1	WHZ2	WHZ3	WHZ4	HAZ 1	HAZ2	HAZ3	HAZ4
Increased Wealth	-0.43 (0.00)	-0.37 (0.00)	-0.29 (0.00)	-0.09 (0.004)	0.23 (0.00)	0.16 (0.00)	0.03 (0.45)	0.014 (0.68)	-0.023 (0.49)	0.09 (0.01)	0.013 (0.71)	0.03 (0.31)	0.003 (0.93)	-0.01 (0.86)	0.089 (0.01)
Increased Mother education	-0.24 (0.00)	-0.28 (0.00)	-0.10 (0.003)	-0.20 (0.00)	0.13 (0.00)	0.06 (0.07)	0.07 (0.05)	0.04 (0.29)	0.01 (0.70)	0.004 (0.90)	0.003 (0.94)	0.10 (0.00)	0.09 (0.01)	0.08 (0.02)	0.10 (0.003)
Increased Family size	0.09 (0.004)	-0.01 (0.82)	-0.02 (0.67)	0.11 (0.001)	0.02 (0.63)	0.06 (0.10)	-0.07 (0.04)	-0.02 (0.49)	0.02 (0.64)	-0.04 (0.20)	-0.06 (0.07)	-0.05 (0.19)	-0.03 (0.46)	-0.04 (0.22)	-0.03 (0.41)
Increased Maternal age	0.19 (0.00)	0.08 (0.02)	0.06 (0.07)	-0.11 (0.002)	-0.09 (0.01)	0.05 (0.13)	-0.01 (0.71)	0.01 (0.74)	0.03 (0.32)	0.01 (0.88)	0.09 (0.01)	-0.03 (0.39)	-0.04 (0.26)	-0.04 (0.24)	-0.08 (0.02)
Increased Child age								-0.01 (0.86)	-0.02 (0.66)	-0.13 (0.00)	-0.19 (0.00)	-0.23 (0.00)	-0.18 (0.00)	-0.12 (0.00)	-0.07 (0.05)
Child sex								0.008 (0.80)	0.01 (0.76)	0.06 (0.07)	0.06 (0.09)	0.04 (0.29)	0.03 (0.40)	0.024 (0.49)	0.027 (0.43)
HFI1					-0.31 (0.00)	-0.37 (0.00)	-0.17 (0.00)	-0.08 (0.014)	-0.08 (0.02)	-0.13 (0.00)	-0.14 (0.00)	0.013 (0.69)	0.04 (0.19)	0.05 (0.13)	0.04 (0.27)
HFI2						-0.27 (0.00)	-0.19 (0.00)		-0.07 (0.048)	-0.06 (0.09)	-0.11 (0.001)		-0.08 (0.02)	-0.07 (0.04)	-0.05 (0.15)
HFI3						-0.42 (0.00)	-0.08 (0.02)			-0.21 (0.00)	-0.13 (0.00)			0.02 (0.51)	-0.14 (0.69)
HFI4							-0.28 (0.00)				-0.22 (0.00)				0.11 (0.002)
FD1								-0.05 (0.11)	0.01 (0.79)	-0.06 (0.08)	-0.02 (0.54)	0.13 (0.00)	0.13 (0.00)	0.13 (0.00)	0.09 (0.01)
FD3										0.19 (0.00)	0.17 (0.00)			-0.13 (0.00)	-0.096 (0.005)
FD4											0.049 (0.15)				-0.047 (0.18)

HFI1 = Household food insecurity score in season 1, FD1 = Food diversity score in season 1, WHZ1 = weight-for-height Z scores in season 1, HAZ 1 = Height-for-age Z score in season 1; Numbers next to acronyms indicated for seasons. For example, 1 = season 1, 2 = season 2, 3 = season3 and 4 = season 4

and December) were better than the food-scarce, pre-harvest seasons (March and June). Seasonal variation was observed for food insecurity, acute malnutrition (wasting), and chronic malnutrition (stunting). Acute malnutrition (wasting) decreased as the household food insecurity decreased. The prevalence of stunting increased one season later than the increase in household food insecurity prevalence. See Figure 3 for information.

Household dietary diversity

The mean household dietary diversity score was 5 food groups per day. The household's consumption of food groups showed seasonal variations: the number of households who had lowest food diversity (≤3) was higher in March (32%, 285 of 879) than in September (22%, 185 of 854) and December (6%, 48 of 830). These findings indicate that the pre-harvest season (season of scarcity) of March had the least diet diversity as compared to post-harvest seasons (September and December). See the table for the overall dietary diversity across three seasons (Table 3).

Regarding responses to household dietary diversity items (Figure 4), the highest consumed food group was condiments that accounted for 2,493 (97%) followed by food groups such as of cereals which was 2,330 (90%). The least consumed food group was fish and eggs, and they accounted for 3%. In
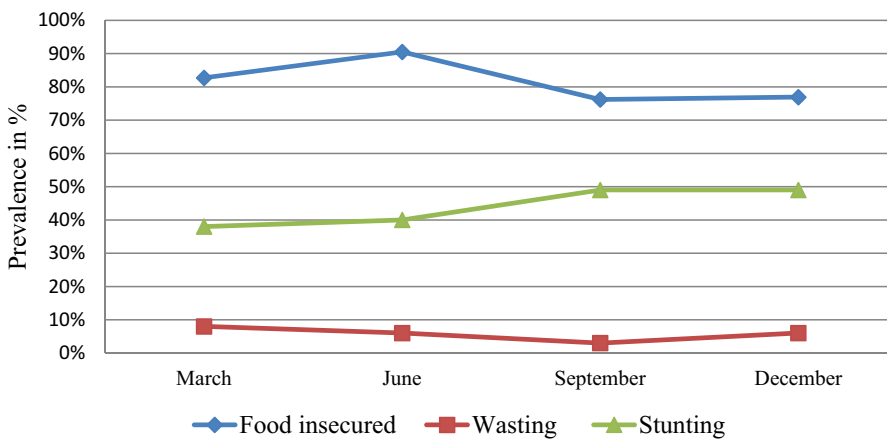

Figure 3. Seasonal variation trend line of food insecurity, wasting, and stunting among children under age five years, Boricha, South Ethiopia, 2017.

Table 3. The overall seasonal pattern of household food consumption, Boricha, Southern Ethiopia, 2017.

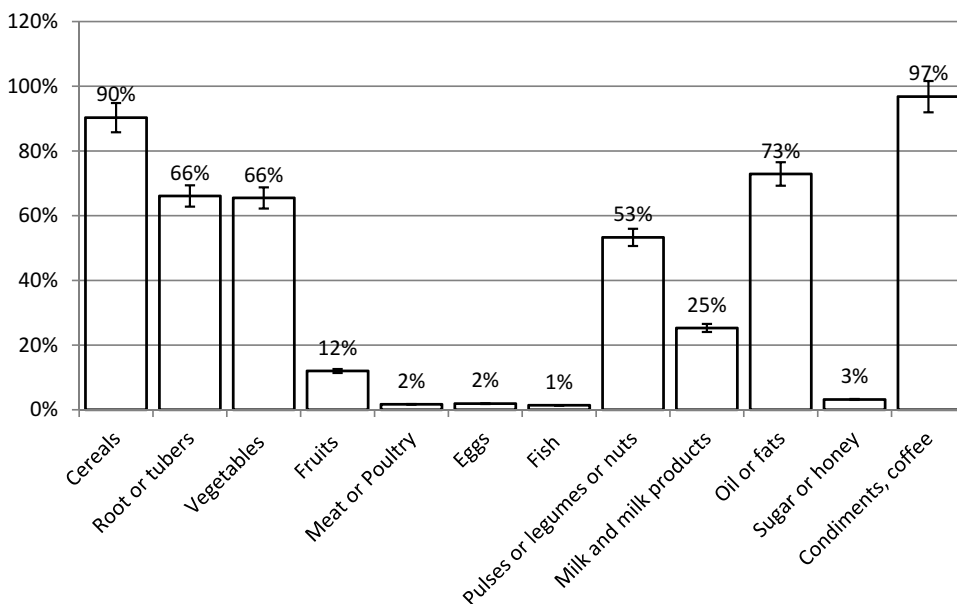| Season	Lowest (≤ 3) food groups	Above 4 food groups	X²	P-value	Odds ratio	95% confidence limit
March	285 (32.2%)	599 (67.8%)	Ref	Ref	Ref	Ref
September	185 (21.5%)	675 (78.5)	25	< 0.001	0.58	0.46–0.71
December	48 (5.8%)	785 (94.2%)	191	< 0.001	0.13	0.09–0.18

Figure 4. Frequency of utilizing twelve food groups in the past 24 hours, Boricha, South Ethiopia, 2017. Bar with 95% confidence level.

general, animal source foods such as meat, eggs, and fish were less frequently consumed.

Evaluation of seasonal pattern for the food groups shows that, except for roots or tubers and fish, there was a significant variation across the different seasons. The pre-harvest season of March had significantly lower use of foods such as cereals, vegetables, fruits, meat or poultry, eggs, sugar compared to post-harvest season of September. Similarly, the pre-harvest season of March had a significantly lower proportion of consumption to most of the dietary diversity food group as compared to the post-harvest season of December. The consumption of animal source foods (meat, egg, and fish) contributed less than 5% for household dietary diversity across the different seasons. The overall association of each food group across different seasons is listed in Table 4.

Wasting

From 3,520 observations in Boricha, about 6% (202 of 3,520 children; 95% CI: 5.0–6.6) of children were wasted. The wasting prevalence was highest among children aged less than 1 year, which was about 12% (18 out of 148 children). Wasting prevalence was 5% (38 out of 754) among children aged between 12 and 23 months, 6% (48 out of 850) children aged between 24 and 35 months, and 6% (94 out of 1,691) children aged greater than 36 months.

Table 4. Seasonal patterns in household dietary diversity (HDDS) items, Boricha, Southern Ethiopia, 2017.

| S.No	Items	March, 2017	September, 2017	December, 2017	X^2	P-value
1	Cereals	697 (78.2%)	808 (94.3%)	825 (99.0%)	236	P < .001
2	Root or tubers	583 (65.6%)	560 (65.1%)	562 (67.6%)	1	P > .05
3	Vegetables	244 (27.4%)	687 (79.9%)	759 (91.3%)	895	P < .001
4	Fruits	100 (11.4%)	141 (16.5%)	67 (8.1%)	29	P < .001
5	Meat or poultry	9 (1.0%)	33 (3.8%)	3 (0.4%)	34	P < .001
6	Eggs	15 (1.7%)	32 (3.73)	3 (0.36%)	26	P < .001
7	Fish	11 (1.2%)	13 (1.5%)	13 (1.6%)	0.4	P > .05
8	Pulses or legumes	374 (42.1%)	369 (43.0%)	631 (76.0%)	254	P < .001
9	Milk and milk product	250 (28.3%)	258 (30.1%)	140 (17.0%)	45	P < .001
10	Oil or fats	607 (68.1%)	599 (70.2)	667 (80.8%)	40	P < .001
11	Sugar or honey	23 (2.6%)	45 (5.3%)	13 (1.6%)	20	P < .001
12	Condiments, coffee	840 (94.2%)	837 (98.0%)	816 (98.3%)	30	P < .001
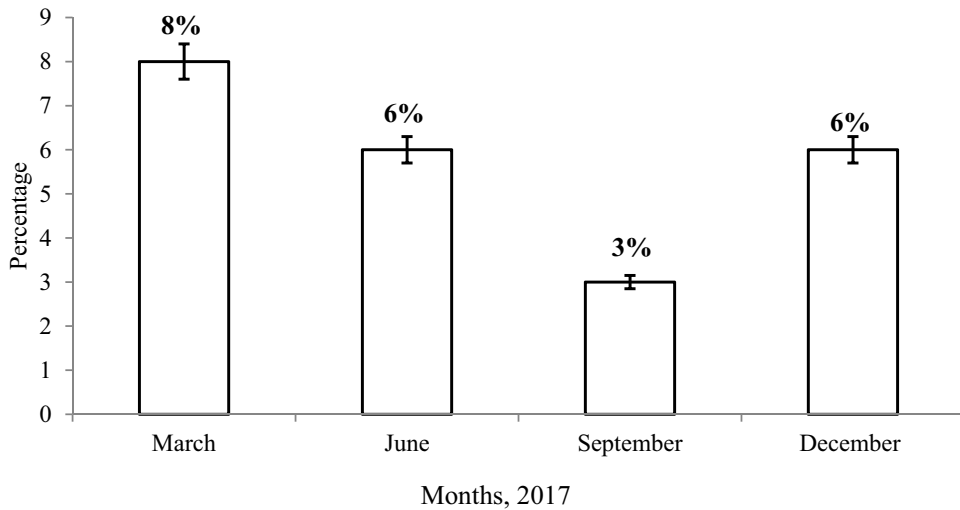
Figure 5. Seasonal variation of wasting among children under age five in Boricha, South Ethiopia, 2017. Bar with 95% confidence level.

The prevalence of wasting increased in the pre-harvest season: As shown in Figure 5, the prevalence of wasting showed seasonal variations: 8.2% (73 of 892 persons) in March 2017 (95% CI: 6.1–10.8) and 3% (27) in September 2017 (95% CI: 2.1–4.5).

Bivariate risk analysis showed that the risk of child wasting was highest among poor households, among households with less educated fathers, among food-insecure households, among households with child sickness in the past 2 weeks, and in March.

Multivariate risk assessment showed that the risk of child wasting increased among poor households, households with less educated fathers, food-insecure households, households whose children were sick in the past 2 weeks, and in March. See Table 5 for more information.

Stunting

From 3,488 observations, about 44% (1,533 of 3,488) of children were stunted (95% CI: 42.3–45.6). Stunting prevalence increased with age, with higher prevalence among children older than 36 months of age. Stunting prevalence was 27% (40 out of 151) among children aged less than 12 months, 43% (325 out of 760) children aged between 12 and 23 months, 42% (367 out of 872) children aged between 24 and 35 months, and 47% (801 out of 1,705) children aged 36 months and older.

Stunting occurred some months after the period with the highest prevalence of food insecurity and showed significant seasonal variations: 38% (338 of 894 persons) in March (95% CI: 34.7–41.0) and 49% (415 of 845 persons) in December (95% CI: 45.8–52.5), as shown in Figure 6.

Bivariate analysis showed that the risk of child stunting was highest among poor households and among households with parents who did not have formal education, parents who had other occupations (e.g., daily laborer, maid), household dietary diversity, and non-exclusively breastfed children. The risk peaked in December.

Multivariate analysis showed an increased risk of child stunting in December 2017, as well as among households that had less educated mothers, food-secured households, and whose parents had other occupations. See Table 6 fordetailed information.

Discussion

Our cohort study demonstrates that some of the possible underlying causes of child wasting and stunting were lack of food access, low food utilization, and marked seasonal variations of food security. Household food insecurity and prevalence of wasting increased in the pre-harvest season, with the highest prevalence of wasting occurring in the same season as the highest prevalence of food insecurity. However, stunting occurred some months after the period with the highest prevalence of food insecurity. This took place in an area of ecological degradation, high population pressure, and repeated droughts. As background information, we demonstrate that basic household factors such as poverty and education were associated with both stunting and wasting.

The prevalence rates of wasting were similar to consecutive Ethiopian Demographic Health Surveys (CSA 2016, 2012, 2001, 2006). The highest prevalence of stunting was recorded during the post-harvest period, similar to the 45% to 51% prevalence rates described for a drought-prone area in the Rift Valley in Central Ethiopia (Gari et al. 2018) and the 51% rate recorded in the Ethiopian Demographic Health Survey 2005 (CSA 2006). Previous studies show that rates of childhood stunting have decreased in Ethiopia, primarily among the more wealthy segments of the population (Golan et al. 2019; Wirth

Table 5. Multivariate risk factor of wasting under the age of 5 years in nine Kebele, Boricha, Southern Ethiopia, 2017.

| Variables		Cases among participants				Crude OR (95% CI)		Adjusted OR (95%CI)	
		Yes (N)	%	No (N)	%	OR	95% CI	OR	95% CI
Wealth quintile	Poorest	40	5.7	658	94.3	1.40	0.71–2.76	0.96	0.48–1.91
	Poor	43	5.9	683	94.1	1.19	0.83–1.69	1.08	0.76–1.53
	Medium	49	7.4	615	92.6	1.40	1.04–1.88*	1.32	1.04–1.68*
	Rich	30	4.3	665	95.7	0.80	0.46–1.38	0.72	0.40–1.27
	Richest	36	5.2	657	94.8	1	Ref	1	Ref
Food security	Secure	20	3.2	601	96.8	0.49	0.32–0.73**	0.55	0.37–0.80**
	Mild	10	3.7	257	96.3	0.60	0.28–1.27	0.83	0.39–1.74
	Moderate	29	5.3	518	94.7	0.67	0.46–0.98*	0.81	0.49–1.30
	Severe	142	6.9	1924	93.1	1	Ref	1	Ref
Season	Wasting in March 2017	73	8.2	819	91.8	1	Ref	1	Ref
	Wasting in June 2017	51	5.7	850	94.3	0.64	0.36–1.13	0.76	0.39–1.46
	Wasting in September 2017	27	3.1	845	96.9	0.32	0.19–0.55***	0.47	0.29–0.74**
	Wasting in December 2017	51	6.0	804	94.0	0.68	0.31–1.49	1.05	0.53–2.09
Mother's age		196	5.6	3,270	94.4	0.99	0.96–1.03	0.99	0.95–1.03
Mother's occupation	Housewife and farmer	172	5.7	2837	94.3	0.82	0.36–1.85	0.88	0.33–2.37
	Employed/merchant	19	4.8	374	95.2	0.59	0.18–1.97	0.62	0.14–2.76
	Others	7	8.3	77	91.7	1	Ref	1	Ref
Mother's educational status	Primary	1411	94.2	87	5.8	1.04	0.77–1.42	1.38	0.94–2.03
	Secondary and above	147	95.5	7	4.5	0.73	0.28–1.94	1.02	0.27–3.88
	No formal education	1602	94.2	99	5.8	1	Ref	1	Ref
Father's educational status	Primary	88	5.0	1659	95.0	0.66	0.48–0.91*	0.66	0.47–0.93*
	Secondary and above	22	5.3	392	94.7	0.68	0.39–1.15	0.60	0.24–1.50
	No formal education	89	6.8	1224	93.2	1	Ref	1	Ref
Father's occupation	Farmer	116	5.3	2081	94.7	0.70	0.46–1.08	0.63	0.39–1.04
	Merchant	52	5.7	868	94.3	0.67	0.36–1.25	0.70	0.35–1.43
	Others	29	8.0	332	92.0	1	Ref	1	Ref
Child sex	Male	120	6.3	1796	93.7	1.19	0.98–1.45	1.13	0.95–1.35
	Female	82	5.1	1522	94.9	1	Ref	1	Ref
Morbidity	No	133	4.8	2646	95.2	0.41	0.23–0.71**	0.42	0.25–0.69**
	Yes	68	9.6	641	90.4	1	Ref	1	Ref

*p <.05, **p <.01, and ***p <.001
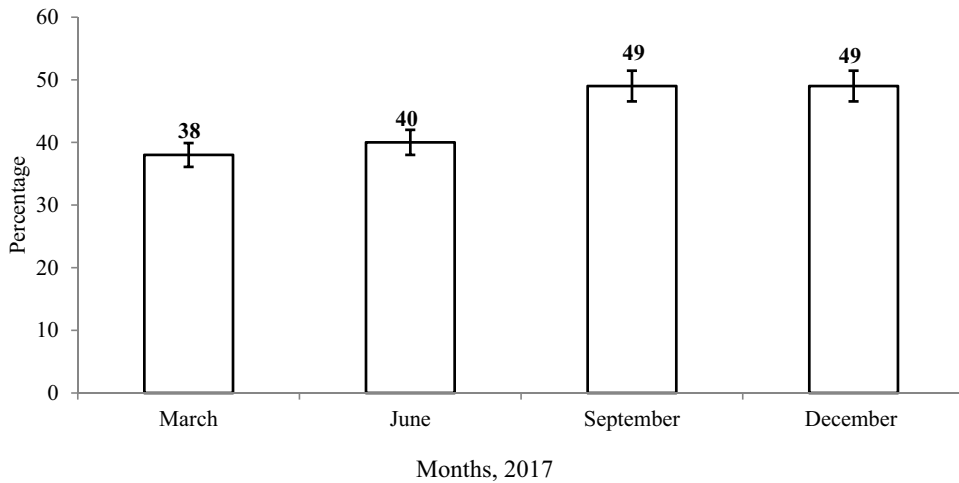
Figure 6. Seasonal variation in stunting among children under age five, Boricha, South Ethiopia, 2017. Bar with 95% confidence level.

et al. 2017). The possible reason for the constant trend of wasting and stunting in Ethiopia could be due to persistent low socio-economic status of the country (UNDP 2019) and inequalities between rural and urban (Tranvåg, Ali, and Norheim 2013)

Regarding household food insecurity, more than two thirds of households had manifested food insecurity in all seasons. Similarly, cross-sectional studies conducted in Boricha in 2012 (Regassa and Stoecker 2012) and elsewhere in South Ethiopia (Asesefa Kisi et al. 2018; Betebo et al. 2017; Hagos et al. 2015) had high prevalence rates of food insecurity. Moreover, our finding was higher than the national survey (35% of household food insecurity) (Humphries et al. 2015). Thus, our study shows that there was no improvement in the household food security situation in this part of the country.

The intake of animal source food and fruits were low, and this is similar to findings from other developing countries (Bosha et al. 2019; Campbell et al. 2014; Hirvonen, Taffesse, and Worku Hassen 2016). However, we found a high intake of carbohydrate source foods which indicates the monotonous nature of the diet (Table 6). This indicates for most of the rural households are unable to afford the high price of animal source food (Hirvonen and Wolle 2019), and thus suggests inadequate micronutrient intake (Arimond et al. 2010).

Furthermore, our study confirmed the risk factors for stunting and wasting in Ethiopia found in other studies. For example, the risk of child wasting increased with decreasing the wealth status of households (Greffeuille et al. 2016). This finding suggests that reducing poverty with a pro-poor economic growth policy could reduce malnutrition. Stunting and wasting also were higher among parents who did not have formal education, and children of

Table 6. Multivariate risk factor for stunting among children younger than 5 years in nine kebele in Boricha, Southern Ethiopia, 2017.

Variables		Cases among participants				Crude OR (95% CI)		Adjusted OR (95% CI)	
		Yes (N)	%	No (N)	%	OR	95% CI	OR	95% CI
Wealth quintile	Poorest	354	51.2	337	48.8	4.99	1.80–13.83**	3.10	0.88–10.98
	Poor	319	43.9	408	56.1	3.02	1.22–7.43*	2.17	0.74–6.41
	Middle	279	42.1	384	57.9	1.56	0.53–4.58	1.37	0.42–4.49
	Rich	315	44.5	393	55.5	1.39	0.92–2.09	1.43	0.88–2.32
	Richest	254	37.5	424	62.5	1	Ref	1	Ref
Food security	Secure	271	43.8	348	56.2	1.98	1.05–3.74*	1.36	0.78–2.36
	Mild	148	56.5	114	43.5	3.02	1.26–7.24*	1.81	1.19–2.76*
	Moderate	229	42.2	314	57.8	1.55	1.04–2.31*	0.97	0.63–1.49
	Severe	879	43.0	1165	57.0	1	Ref	1	Ref
Season	Stunting in March 2017	338	37.8	556	62.2	0.25	0.09–0.73*	0.26	0.09–0.72**
	Stunting in June 2017	354	40.0	532	60.0	0.31	0.12–0.84*	-	-
	Stunting in September 2017	426	49.4	437	50.6	0.95	0.28–3.22	0.97	0.29–3.11
	Stunting in December 2017	415	49.1	430	50.9	1	Ref	1	Ref
Mother's education	Primary	635	40.8	923	59.2	0.47	0.28–0.79**	0.49	0.21–1.14
	Secondary and above	39	24.7	119	75.3	0.14	0.07–0.29***	0.38	0.16–0.89*
	No formal education	851	48.6	901	51.4	1	Ref	1	Ref
Mother's occupation	Farmer and housewife	1350	45.0	1649	55.0	0.37	0.19–0.69**	0.13	0.03–0.49**
	Employed/merchant	140	35.6	253	64.4	0.15	0.05–0.42***	0.08	0.02–0.37**
	Others	42	49.4	43	50.6	1	Ref	1	Ref
Mother's age		1,510	43.7	1,947	56.3	1.04	0.99–1.08	0.97	0.93–1.02
Child sex	Male	860	45.5	1030	54.5	1.48	0.84–2.59	1.57	0.81–3.02
	Female	673	42.1	925	57.9	1	Ref	1	Ref
Child age	6–23 months	365	40.1	546	59.9	0.76	0.38–1.52	1.25	0.50–3.08
	≥24 months	1168	45.3	1409	54.7	1	Ref	1	Ref
Father's educational status	Primary	757	43.3	990	56.7	0.74	0.42–1.29	1.11	
	Secondary and above	125	30.0	291	70.0	0.19	0.09–0.40***	0.43	0.14–1.32
	No formal education	635	48.8	667	51.2	1	Ref	1	Ref
Father's occupational status	Farmer	1009	46.3	1170	53.7	0.77	0.35–1.72	0.64	0.26–1.57
	Merchant	340	36.9	582	63.1	0.36	0.18–0.71**	0.27	0.11–0.67***
	Others	176	47.8	192	52.2	1	Ref	1	Ref
Exclusive breastfeeding practice	Only breast milk	1358	42.5	1841	57.5	0.09	0.01–0.89*	0.10	0.01–1.35
	Breast and other food items	149	69.3	66	30.7	1	Ref	1	Ref
Household dietary diversity score		1,262	47.1	1,418	52.9	1.16	1.07–1.26***	1.03	0.97–1.09

*p <.05, **p <.01, and ***p <.001

uneducated parents were at higher risk for malnutrition (Hasan et al. 2016; Makoka and Masibo 2015; Victora et al. 1986). Thus, education might improve child care and child feeding practices (Kalanda, Verhoeff, and Brabin 2006), which in turn improves child nutritional status (Saha et al. 2008). Children who had no morbidity in the past 15 days were less likely to be wasted. As diarrheal diseases increase the risk of wasting, it is likely that both food factors and illness contributed to the observed increased rates of wasting (Derso et al. 2017). Hence, improving child nutritional status will require multi-sector approaches. Programs to improve child malnutrition among rural subsistence farming communities should integrate agricultural, educational, and health information. Practically at the local level, our study suggests that the district (Woreda) health office and health extension workers should identify households in need of food, advise them on ways to improve their food diversity and intake and if possible, refer them to the Productive safety net program, and work to prevent diseases associated with malnutrition.

Strengths of the study

Our study area is typical in Ethiopia with recurrent droughts and food shortages. The population was representative of the area, as we randomly selected the kebeles and households. Furthermore, to assess the outcome variables, we conducted a cohort study using four repeated assessments of the same households in four different seasons over a year. The sample size was large and adequate, and the loss to follow-up was small. We also used a multilevel, mixed-effect model to account for both hierarchical effect of response correlation at the kebele level and household level, and longitudinal response of repeated measurements at individual level.

Limitations

The effect of seasonal variations on food insecurity, stunting, and wasting were significant when controlling for confounders. However, our study lasted for only 1 year. Thus, it would be advisable to conduct future studies over longer periods (Lindtjorn and Alemu 2002). Also, our study included only households from rural populations, and hence future studies could include urban households. Most risk factors were assessed from maternal recall, which may have introduced recall bias, although we used a short recall period to reduce such bias. As the study participants may have expected possible aid, they may incline toward affirmative responses of household food insecurity access scale measurement items. Household dietary diversity was not conducted on specific groups, and the consequences of seasonal variation may be higher in specific groups such as mothers or children.

Conclusions and recommendations

Our study suggests that household food insecurity increased the risk of child wasting during the period of highest food scarcity (pre-harvest season; table 8 and Figure 6). Similarly, the risk of low household food consumption increased in the period of the highest food insecurity. Moreover, household characteristics such as poverty level, education, occupation, and the household food insecurity and dietary diversity were associated with subsequent wasting and stunting. Thus, our study links poverty, household food insecurity, and household dietary diversity as indicators of agricultural production, with stunting and wasting in this drought-prone rural farming community. However, our data suggest that household food insecurity was a more pronounced predictor for stunting and wasting than household dietary diversity, as had been suggested by others (Ali et al. 2013). Our research findings could have implications for both designing and evaluating interventions to reduce the state of nutrition in the affected communities.

Possible future knowledge gaps and interventions could focus on increasing household wealth and agricultural production. Crop production capacity of the areas and weather variations from year to year could influence malnutrition, indicating a need to integrate studies on rainfall trends, agriculture, and health, as well as climate change in Ethiopia (Simane et al. 2016). Our study on seasonal changes on food insecurity and dietary diversity underscores increasing challenges in agricultural production in a drought-affected area in Ethiopia. These challenges will continue to erode nutrition security, as has been the case for decades, and it may undermine sustainable livelihood and development efforts in the area (Niang et al. 2014). One potential intervention in food security and diet diversity is to combine the need for improved seasonal forecasting and early warning systems for farmers. Programs working in improving child malnutrition among rural subsistence farming communities could integrate seasonal weather forecasting, health information, and improved education of all, but especially women (Persson, Rasmussen, and Yang 2019). Interventions should consider including high-quality diet such as animal source food and fruits (Hawkes et al. 2020). Moreover, interventions should promote diversity in food production and consumption among poor households living in drought-prone areas. Such an intervention could support decision-making among farmers to reduce societal vulnerabilities and enhance adaptation and resilience to the impacts of climate change (Vaughan and Dessai 2014).

Authorship

M.B., E.L., and B.L. designed the study. All authors participated in the data analysis, drafting of the manuscript, and writing the final article.

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Disclosure statement

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