Dietary practices and nutritional status of children aged 0-24 months and their mothers in the rural ensete-monoculture dominated Sidama region, Ethiopia

Tsigereda Behailu Kebede

Thesis for the degree of Philosophiae Doctor (PhD)
Hawassa University, Ethiopia and
University of Bergen, Norway
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Academic environment

This is a joint PhD programme between Hawassa University, Ethiopia and the University of Bergen, Norway. The programme is funded by the Norwegian Programme for Capacity Development in Higher Education and Research for Development (NORHED) through the Southern Ethiopia Network of Universities in Public Health (SENUPH) project. As part of its aim to increase the number of PhD degree holders, particularly of female academics, the project recruited PhD students from three universities in southern Ethiopia. I was one of those who were given that opportunity. The training, mainly the coursework, was given at both of the universities. The research project was fully implemented in Ethiopia under the close supervision of the University of Bergen and Hawassa University. Professor Ingunn Marie S. Engebretsen from the University of Bergen, Centre for International Health (CIH), was my principal supervisor, and Dr. Selam Mengesha from Hawassa University and Professor Bernt Lindtjorn from the University of Bergen (CIH) were my co-supervisors. This research project was carried out in a typical rural Dale district, Sidama region, Ethiopia, in order to study the dietary and nutritional situation of young children and their mothers.

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Summary

Background: Ethiopia is a low-income country with a high burden of child and maternal undernutrition. Although overnutrition is on the rise among different groups of the population, undernutrition is still dominant in many rural and less privileged parts of the country. Sub-optimal dietary intakes are among the common factors associated with undernutrition.

Most studies in Ethiopia focus on urban and semi-urban areas with relatively better access to transportation and health facilities. However, few studies exist from rural and less privileged areas. The dietary aspects of the rural ensete-monoculture dominated Sidama region were assessed a few decades ago. The background to this thesis was understanding the current dietary aspects of this rural community, particularly for young children and mothers.

Objectives: The aim of this thesis is to describe the dietary practices and nutritional status of young children and mothers in the rural ensete-monoculture dominated Sidama region, Ethiopia. It also aims to analyse the dietary and non-dietary risk factors for undernutrition among children below the age of two and their mothers. It also investigates the consumption of animal-source foods among children and mothers.

Method: A total of 985 households with children under the age of two and their mothers aged between 15 and 49 were randomly selected from seven rural kebeles. Data on sociodemographic characteristics, anthropometric measurements, haemoglobin level assessments and dietary recalls was obtained. Household food access was also assessed, using the household food insecurity access scale tool. Animal-source food consumption frequencies among children and mothers were also assessed and analysed in relation to household livestock ownership. EpiData version 3.1 was used to double-enter and validate the data. SPSS version 25 was used to clean and describe the data. SPSS version 25 and STATA version 15 were used for further analysis. Multilevel linear regression was used for Paper I and Paper II, and ordinal logistic regression was used for Paper III.

Result: In Paper I, we found that stunting among children aged 0-24 months was 39.5% and that the majority of the children (61.7%) were anaemic. The prevalence of household food insecurity was 74.9%. Age, sex, haemoglobin level of the child and household food insecurity were significant factors associated with faltering linear growth among children younger than 24 months. In Paper II, the prevalence of anaemia and underweight among mothers were 12.8% and 12.6%, respectively. Determinants of mothers' haemoglobin levels were weight, dietary diversity score and educational status. Household wealth and the dietary diversity scores of the mothers were also factors positively associated with the mother's anthropometric status. The minimum dietary diversity prevalence among children was 39.1% (Paper I) and that of the mothers was 38% (Paper II). In Paper III, we described animal-source food consumption frequencies among children and mothers during a month prior to our study. Any dairy consumption among children was 91.8%, and 96% among mothers. While egg consumption among children was 83%, it was 50% among mothers. Meat consumption was reported for 26.2% of the children and for 34% of the mothers. Nearly, three-quarters (631 out of 851 households) owned cows and a quarter (213 out of 851 households) kept goats or sheep.

Conclusion: We found that child undernutrition, anaemia and stunting were major problems in the rural area. Anaemia was a mild public health problem, while being underweight was a medium public health problem among mothers with children below the age of two, according to the WHO classification criteria [1, 2]. We also described low-diversified diets among children and mothers and high food insecurity. Planning and implementing short-term and long-term strategies to improve access to nutritious foods and sustainable food security require consideration.

List of original papers

Paper I

Kebede, T.B., Mengesha S, Lindtjorn B, Engebretsen I. M. S. (2022)

Dietary practices and nutritional status of young children in the former ensete-monoculture dominated Sidama region, southern Ethiopia: A community based cross-sectional study.

PLoS ONE 17(9): e0272618. https://doi.org/10.1371/journal.pone.0272618

Paper II

Kebede, T. B., Mengesha, S., Lindtjorn, B., & Engebretsen, I. M. S. (2022)
Anaemia, anthropometric undernutrition and associated factors among mothers with children younger than two years of age in the rural Dale district, southern Ethiopia: A community-based study.
Maternal & Child Nutrition, e13423. https://doi.org/10.1111/mcn.13423

Paper III

Kebede, T. B., Mengesha, S., Lindtjorn, B., & Engebretsen, I. M. S.
Does livestock ownership contribute to the frequency of animal-source food consumption among children aged 6-24 months and mothers in Dale district, southern Ethiopia? (Submitted)

Abbreviations

AOR	Adjusted Odds Ratio
BMI	Body Mass Index
CI	Confidence Interval
CSA	Central Statistical Agency
EDHS	Ethiopian Demography and Health Survey
ENA for SMART	Emergency Nutrition Assessment for Standardized Monitoring Assessment of Relief and Transitions
FANTA	Food and Nutrition Technical Assistance
Hb	Haemoglobin
HFIAS	Household Food Insecurity Access Scale
ICF	International Classification of Functioning
IDA	Iron Deficiency Anaemia
LAZ	Length-for-Age z-score
MUAC	Mid-Upper Arm Circumference
OLR	Ordinal Logistic Regression
OR	Odds Ratio
REK West	Regional Committees for Medical and Health Research Ethics of Western Norway
SD	Standard Deviation
SENUPH	South Ethiopia Network of Universities in Public Health
UNICEF	United Nations International Children’s Emergency Fund
UOR	Unadjusted Odds Ratio
WAZ	Weight-for-Age z-score
WHO	World Health Organization
WLZ	Weight-for-Length z-score

Operational definitions

Age at first pregnancy: the age of the mother during her first pregnancy that she chooses to report.

Anaemia: an altitude-adjusted haemoglobin level below 11g/dl for children below two years of age and an altitude-adjusted haemoglobin level below 12 g/dl for mothers.

Animal-source food consumption: consumption of dairy products, eggs and any type of meat.

Birth order: the birth order of the child as compared to their biological siblings.

Complementary feeding: any liquid, solid or semi-solid food other than breast milk given to the child.

Dietary diversity score (DDS): information on consumption of the pre-listed food items during the 24 hours prior to the study. Using this information, the food items were grouped and assigned a score of '0' and '1' to indicate the level of consumption from each of the food groups. Finally, the scores were summed up to determine DDS.

Educational status: the highest educational level the mother has completed.

Family planning method use: the use of any method, including hormonal, barrier or the safe periods (rhythm) method for the purpose of preventing pregnancy.

Household food insecurity score (HFIS): a score ranging from 0 to 27 calculated for the nine household food insecurity questions (HFIAS tool) coded as 'yes or no'; and all 'yes' responses further coded into three scores (1= rarely or 1-2 times, 2= sometimes or 3-10 times, and 3= often or more than 10 times) in the past four weeks. Based on the score, households were classified into four categories: food secure, mildly food insecure, moderately food insecure and severely food insecure.

Household size: the number of people living in a household and sharing food and other household utensils together.

Linear growth: a measure of child's length to their age among children below the age of two and described as a length-for-age z-score.

Livestock ownership: presence of animals: cows, sheep, goats, oxen, donkeys and hens in the household.

Main source of drinking water: the source used to obtain drinking water for the household demand, classified as improved and non-improved source. Improved source includes piped water, protected spring or well water, while unprotected spring, well or river water are non-improved sources.

Place of delivery: information about whether the index child participating in this study was born at home or at a healthcare institution.

Staple food: the starchy food item most frequently used by the family as a main dish of the household.

Stunted child: a child with a length-for-age z-score which is < -2SD from the reference population, based on the WHO, 2006 child-growth standards.

Time of starting breastfeeding: the time the participating child was first put to the breast after delivery.

Total number of pregnancies: the total number of pregnancies ever faced, irrespective of the outcome

Underweight mother: a mother with a body mass index which is less than $18.5 kg/m^2$.

Wealth index: an asset-based constructs ranked into three categories: lower, middle, and upper wealth status.

Woman in the reproductive age group: a woman aged 15 to 49.

Young child: a child aged below two years or 24 months.

Introduction

What is this thesis about?

Mothers in the reproductive age group and children below the age of two are highly vulnerable to undernutrition [3, 4]. The nutritional status of a mother may affect her reproductive physiology, and may have been determined when she herself was a foetus. There is thus a need to break the vicious intergenerational cycles of undernutrition and to document whether there are changes over time [5]. Countries in the sub-Saharan region account for a high burden of child and maternal undernutrition [6]. The prevalence of child undernutrition has been persistently high, combined with the double burden of malnutrition in low-income countries compared to middle-income countries [3]. Despite some improvements in the sub-Saharan region over some decades, the prevalence of child stunting is reported at over 40% [7]. The double burden of malnutrition is the co-existence of undernutrition and overnutrition in the same population, household or person [8]. The double burden of malnutrition is also increasing globally, with the highest magnitude in low- and middle-income countries [9, 10]. Ethiopia is a low-income country, with an estimated population of 110 million, and nearly 80% of the population depend on agricultural activities [11]. In Ethiopia, both undernutrition and overnutrition are major public health problems. Even though undernutrition has persisted over decades and is a priority issue in Ethiopia, overweight and obesity are also increasing. The national prevalence of overweight among mothers in the reproductive age group was 8% in 2016 [12]. Studies of different regions of Ethiopia also reported a high prevalence of overweight among women in the reproductive age group: 28.2% in Hawassa city [13] and 63% in Dire Dawa, eastern Ethiopia [14]. Other studies from Ethiopia have reported a high prevalence of maternal and child undernutrition and the factors contributing to it [15, 16]. The magnitude of undernutrition and the existing dietary practices of mothers and children in a typical rural ensete-monoculture dominated area have been studied less, to the best of our knowledge. Our study aims to answer the following questions from the rural Sidama region:

1. What is the situation of young children with regard to feeding practices, anthropometric status and the magnitude of anaemia, and what are the risk factors for child undernutrition in this typical rural area? (Paper I)
2. What is the situation of mothers in the reproductive age group with regard to dietary practices, prevalence of anaemia and anthropometric status during the two years after giving birth, and what influences their nutritional situation? (Paper II)
3. Does household livestock ownership contribute to the level of animal-source food consumption among young children and mothers in this rural area? (Paper III)

To answer these questions, we conducted a community-based comprehensive cross-sectional study to assess the dietary practices, food insecurity status and nutritional status of children aged below two and their mothers.

Malnutrition

Malnutrition is a general term that refers to all forms of undernutrition, overweight, obesity and micronutrient imbalances [17, 18]. As said, even though overnutrition and the double burden of malnutrition are on the rise, most low- and middle-income countries are challenged by the burden of undernutrition [6, 19].

The nutritional status of children and mothers can be assessed by anthropometric, clinical and dietary methods [20]. Anthropometry refers to the measurement of weight, height, mid-upper arm circumference, waist circumference, skin fold and other body dimensions used to assess nutritional status [20]. Anthropometric assessments are non-invasive, relatively inexpensive, and easy to apply as a screening method [21].

Dietary assessment refers to the collection of information about the intake of food and drink using different methods and time durations [20]. Twenty-four hour dietary recalls and food frequency questionnaires are retrospective methods used to assess the dietary intake of individuals [20, 22]. Biochemical assessments also involve measuring the concentration of nutrients or their biomarkers in the body [20, 23]. I will describe assessment techniques relevant for undernutrition at population level below.

Twenty-four recall is a method used to assess the intake of food and drink over 24 hours [24] and can also include portion estimation. It can take place as a single 24-hour recall or as multiple 24-hour recalls which involve consecutive or intermittent days [22]. As a common dietary assessment method 24-hour recall has advantages and limitations. One advantage is that it does not require a long-term memory, which minimises the recall bias. It can take place relatively quickly, if a structured interview is used, or it may take longer if we use the chronological gold standard [22]. On the other hand, portion size estimation and conversion to weight equivalent is time consuming and may introduce errors [25].

Food frequency questionnaire is another retrospective method used to assess dietary intake over a longer period. This method is used to assess usual food intake, and intake of specific food groups and nutrients, and the responses are often recorded on a Likert scale indicating frequency of intake [20, 26]. Food frequency questionnaires also present the advantages of low respondent burden and large coverage, and can capture foods rarely eaten. The limitations include reliance on longer-term memory and that the day-to-day variations in food intake are not captured [20, 22]. Other examples of dietary assessment at national, household and individual level include a food balance sheet, household record and weighed food record, respectively [22].

Biochemical assessment also entails the measurement of specific nutrient markers in different body fluids or tissues, in order to diagnose nutritional deficiencies [20]. Venous blood phlebotomy is common, although for field purposes capillary blood is also sometimes used, as in this thesis.

Undernutrition at any age can have negative health outcomes, although early years and childbearing age are associated with greater negative short-term and long-term consequences [18, 27]. Low immune status, poor cognitive performance and reduced productivity are some examples of the negative consequences of child undernutrition [2, 28, 29]. Impaired foetal growth, low birth weight, anaemia and susceptibility to infection are also consequences of maternal undernutrition, ultimately resulting in higher child and maternal morbidity and mortality [30].

Anaemia

Micronutrient undernutrition refers to a deficiency of vitamins and minerals [18]. Iron deficiency is the most common form of micronutrient deficiency globally and is estimated to account for over 50% of all anaemia cases, with huge regional variations [28, 29]. By definition, anaemia is a condition in which there is a low haemoglobin concentration or low red blood cell count [2, 31]. There are a variety of causes and types of anaemia, which can be roughly classified into nutritional and non-nutritional anaemia [32]. Another classification system also considers cell characteristics, whereby nutritional anaemia may be micro- normo- or macrocytic. The red blood cell characteristics may all be associated with nutritional deficiencies, and the respective deficiency may predispose for specific cell characteristics. For example, iron deficiency is often associated with microcytic anaemia, and vitamin B and folate deficiencies are often associated with macrocytic anaemia. Normocytic anaemia may be found for all deficiencies; and regular undernutrition is also associated with normocytic anaemia. The common causes of iron deficiency are inadequate dietary intake, particularly foods with low nutrient content; poor absorption, which might be related to the actual food, gut conditions and diseases; excessive loss (e.g. bleeding); and increased requirements (e.g. pregnancy, lactation, infancy and infections) [33]. Cereal-based dietary practices are also associated with decreased iron absorption, due to phytates found in most grains [34]. Anaemia should ideally be assessed so that classification and staging is possible. In 2017, WHO recommended that inflamation and iron depletion should be fully assessed, in addition to haemoglobin level and characteristics of red blood cells. These assessments would require access to proper laboratories and are thus unfortunately not always feasible for field studies. Although diagnostic, on-site assessment of haemoglobin level measurement is not a comprehensive approach for anaemia assessment [35]. It does not distinguish between anaemia types or nutritional/or iron depletion from other causes [35, 36]. Haemoglobin level assessment can take place by using an automated haematology analyser or portable HemoCue machine [37]. A portable HemoCue machine is convenient for community screening purposes and field tests [38].

Anaemia can affect any person at any age, but children younger than five years old and mothers in the reproductive age group are more affected [1, 39]. Women in the reproductive age group are biologically vulnerable to iron deficiency anaemia. The reproductive physiology of menstruation, pregnancy, delivery and lactation is nutrition-intensive [40]. Iron deficiency anaemia negatively affects childbearing and the overall health of the mother, unless diagnosed and managed in early pregnancy or before [41].

The World Health Organization's recommendation is multiple micronutrient supplementation (MMS), including iron and folic acid, one to three times a week for all pregnant mothers and menstruating adolescents, rather than iron and folic acid (IFA) supplementation alone [42, 43]. Strategies such as sanitation and malaria prevention are also crucial for the reduction of anaemia [44]. Furthermore, nutrition-based interventions such as increased dietary intake, particularly of animal-source foods, can improve the micronutrient status of mothers [45]. Food fortification with a single or multiple micronutrients is also a useful strategy to improve micronutrient status, particularly in low-and middle-income settings [46].

Iron deficiency anaemia in children, particularly during the first thousand days of life, may result in irreversible long-term deficits such as cognitive and motor impairment [47]. The first thousand days of life refers to the period from conception to the second birthday as a period which is vulnerable to nutritional deficiencies [48]. Prevention, early detection and treatment of anaemia during pregnancy and early childhood are crucial [27, 47, 48]. Among the multiple strategies used to prevent iron deficiency in children, optimal child feeding practices and early detection and treatment of infections are the primary approaches [49]. Early initiation of breastfeeding, exclusive breastfeeding, and appropriate complementary feeding with continued breastfeeding, are the characteristics of optimal child feeding practices [50]. Minimum dietary diversity and minimum meal frequency are also indicators of appropriate complementary feeding [51]. Oral iron supplementation is also an important approach used to prevent and treat iron deficiency [52]. However, iron suplementation in children requires risk-benefit analysis, particularily in malaria-endemic areas [53].

The WHO report indicated that 37.8% (close to 70 million) of non-pregnant mothers living in Africa were anaemic [54]. Pregnancy is an iron-demanding situation, and lactating mothers in Ethiopia are also at high risk of iron deficiency anaemia [55]. Mothers in rural Ethiopia mostly give birth at home and their visits to the healthcare facility after delivery are also limited, accounting for only 14% in the study area [56]. Hence, anaemia among lactating mothers has been found to be associated with chronic inflammation [57]. In Ethiopia, the prevalence of anaemia among mothers aged 15 to 49 was reported at 24% in 2016 [12]. According to the 2019 Ethiopian Demographic and Health Survey (EDHS) report, the percentage of pregnant mothers who took iron supplements for at least 90 days had increased to 11% from 5% in 2016 [58].

Child undernutrition

Child undernutrition includes intrauterine growth restriction, stunting, wasting, underweight and micronutrient deficiency conditions such as anaemia [18]. It is also common to describe child undernutrition as acute or chronic undernutrition. Acute undernutrition is a reflection of a recent situation in which the child failed to gain weight due to inadequate food intake or excessive weight loss [49, 59]. Acute undernutrition (wasting) is defined as a weight-for-height z-score (WHZ) below -2 SD from the WHO child growth standard median [60]. Acute undernutrition among children above the age of six months [61] can also be assessed by a mid-upper arm circumference (MUAC) < 11.5 cm [62]. Recumbent length is used instead of height among children aged below two. Chronic undernutrition (stunting) is defined as a height/length-for-age z-score (H/LAZ) below -2 SD from the WHO child growth standard median [60]. It is a reflection of long-term nutrition deprivation and unhealthy environmental conditions such as poor sanitation [63, 64].

Stunting and wasting, as anthropometric indices, have similarities and differences. The similarities include: both are composite measures derived from two raw data measures and they share some causal pathways [65]. The onset of one increases the risk of the other and their co-occurrence is highly associated with child mortality [66]. This means that nutrition interventions need to target both, in order to reduce the risk of child mortality [66, 67]. The differences between stunting and wasting also include:

- Stunting (linear growth restriction) refers to the cumulative effect of chronic undernutrition related to environmental and socioeconomic circumstances [2, 68]. Wasting, on the other hand, reflects a recent and severe process of weight loss associated with acute starvation or illness, particularly infections [69].

- The prevalence of stunting is used as a measure of community well-being [70, 71], while the prevalence of wasting calls for immediate action at the community level and the emergency management of children [67].
- The management of stunting focuses on prevention through nutrition quality, improved hygiene and sanitation, and overall socioeconomic development, while wasting is quickly reversible if adequate nutrition and effective management of infection are provided [67, 69].

Stunting is a major nutritional problem among children under the age of five [72]. Particularly the first thousand days of life is the window period for the onset of stunting. This period is characterised by active physical growth and mental development requiring optimum nutrition [48, 73]. Stunting and faltering linear growth are used interchangeably to describe chronic undernutrition in children. However, linear growth restriction and stunting have different implications for describing child undernutrition [74, 75]. Linear growth restriction refers to a failure to reach one's linear growth potential (too short for their age), but does not imply that the child is stunted. Stunting, on the other hand, is applied to a child with a height/length-for-age z-score below -2 SD from the standard population median [74, 75]. The number of children with linear growth restriction is higher than the number of children who are stunted (i.e. children with stunting are a subset of children with linear growth restriction).

Weight-for-age (underweight) is a measure of body mass in relation to the age of the child. Underweight is described as a weight-for-age z-score (WAZ) less than 2 standard deviations from the WHO median growth reference [76]. The limitation of WAZ is that it does not distinguish between a short child, with a body weight normal for their height, and a thin child [69].

The global prevalence of child stunting and wasting was 29.1% and 6.3%, respectively [77]. In Ethiopia, the national prevalence of stunting among children under the age of five was reported at 37% in 2019 [58]. The national prevalence of wasting was reported at 7% in 2019. In the same national report, it was indicated that the prevalence of stunting and wasting in southern Ethiopia was 36.4% and 6.3%, respectively, and thereby similar to the national average. However, there are great differences between regions and districts in the same region. In Sidama region, the prevalence of stunting was 14.7% in Hawassa city [78], while it was 45.5% in another district of the region, Wondogenet [79].

In Ethiopia, 57% of children under the age of five were anaemic in 2016 (6). A recent study from Wolayta zone, southern Ethiopia, also reports a high prevalence of anamia (65%) among children aged 6 to 23 months [80]. There was a large regional difference in the prevalence of anaemia in Ethiopia, ranging from 42% in Amhara region to 83% in Somali region in 2016 [12]. Anaemia is associated with poor dietary intake, particularly an inadequate intake of animal-source foods, and stunting [81, 82]. Lack of a safe water supply and poor sanitation are also risk factors in poor settings [83]. In addition, the intake of substances (e.g. coffee and tea) with a meal, or immediately after a meal, can interfere with the absorption of some nutrients, including dietary iron [1, 84].

Maternal undernutrition

Maternal undernutrition is a global concern contributing to an intergenerational cycle of undernutrition [85, 86]. In addition to poverty-related factors affecting the general population, women in the reproductive age group are challenged by the physiology of menstruation, pregnancy and lactation [87]. Being underweight, as an indicator of chronic energy deficiency, is a common form of undernutrition among mothers in poor settings [88].

Body mass index (BMI) is a composite index computed by dividing weight in kg by height in metres squared [89]. BMI is used to describe nutritional status as being underweight, of normal weight, overweight and obese [89]. Underweight is defined as a BMI below 18.5 kg/m^2. Normal BMI is between 18.5 and 24.9 kg/m^2. BMI scores of 25-29.5 kg/m^2, and greater than or equivalent to 30 kg/m^2, are classified as overweight and obese, respectively [90]. Being underweight, overweight or obese are associated with negative outcomes of childbearing for mothers [91, 92].

Almost 10% of women are underweight globally and more than 30% of women in the reproductive age group are anaemic [93, 94]. Maternal underweight in many resource-poor settings is considerably high [95] and in Ethiopia it was reported at 22% in 2016 [12].

Dietary practices

In resource-poor settings, poor dietary intake is a major reason for child and maternal undernutrition [91, 96, 97]. Inadequate intake of both macro- and micronutrients is associated with diets in which no or limited animal-source foods are included [98]. Animal-source foods are rich sources of the high-quality nutrients essential for normal reproductive function and optimal child growth [99, 100]. Milk, for instance, as an important animal-source food nurturing the young, stimulates growth by providing energy, protein and micronutrients [101]. Egg consumption during pregnancy, lactation and early childhood also provides several key nutrients that enhance foetal growth, breast milk composition and child growth, respectively [102]. Meat is a rich source of protein and other nutrients, including iron and vitamin B_{12}, which are either not present in plant-source foods or have poor bioavailability [103]. Fish and poultry are also important micronutrient and protein sources [104, 105].

For children aged above six months appropriate complementary feeding is crucial to ensure normal growth, health and mental development. Complementary feeding is defined as the introduction of foods and liquids to an infant whose nutritional requirements cannot be adequately met with breastmilk alone [106]. Sub-optimal child feeding practices are the common factor associated with poor linear growth and reduced learning capacity among children. In Ethiopia, only 11% of children aged 6-23 months were getting a minimum acceptable diet in 2019 [107]. Sub-optimal child feeding practices are common in different parts of the country, ranging from 42% in Addis Ababa to 98% in Somali [58]. The prevalence of minimum dietary diversity was reported at 35% in northwestern Ethiopia [108]. A study in the drought-prone area of the region reported that animal-source food consumption among young children was 1.9% for meat, fish and poultry, and 3.4% for eggs [109]. Another study in the Jimma zone reported that only 32.8% of lactating mothers in the study area were consuming the minimum dietary diversity [110]. Children and mothers in low-income settings are socially, culturally and economically less privileged in terms of adequate diet. This makes young children, pregnant mothers and lactating mothers suffer from different forms of undernutrition.

An overview of ensete-monoculture in the area

Ensete is a plant of the musaceae family with wild and domesticated species. Ensete is a perennial, monocarpic and evergreen plant known by different names, reflecting its environmental and social values. Ethiopian banana, Abyssinian banana, false banana, a drought-resistant plant, and a tree against hunger are some examples of the names used. Particularly in Ethiopia, ensete (*Ensete ventricosum*) is known for its multiple uses as food, fodder and homemade fibre, and in traditional medicine [111, 112].

Ensete (*Ensete ventricosum)* is a major staple food in the southern and southwestern parts of the country, where more than 20 million people live [113]. The people living in these areas were less affected by the drought and famine occurring in Ethiopia during the years from 1972 to 1985. The pseudostem and the corm of this ‘false banana’ are used for food. However, the food content shows that the plant is rich in carbohydrates (80%) and fibre (7%), and deficient in proteins (4%), fats (0.4%), vitamins and other micronutrients [114, 115]. Most of the people of rural Sidama are farmers who have been cultivating ensete as the main staple food for decades [114, 116, 117]. More recently, however, other food crops, particularly maize and cash crops such as fruit, coffee and chat, have tended to dominate, due to the short harvesting time and greater income generation opportunities compared to ensete [118]. Moreover, the recent rapid population growth [119, 120] has led to small farming areas. The replacement of ensete with maize and other cash crops, and the rapid population growth, ultimately present the risk of food insecurity. However, the impact of these changes on household food security, dietary practices and the nutritional status of children and mothers has not been adequately understood. The detailed assessment of child undernutrition, child feeding practices and dietary practices of adults took place three to five decades ago [116, 121]. The assessment in 1971 [116] focused on dietary practices among children and adults, and another assessment in 1993 also considered the nutritional status of children in the area [121].


a


b

Figure 1: A rural household with ensete plants at the back (a) and an ensete plant grown in an urban household (b) (Pictures were taken by the investigator).

Nutritional intervention in Sidama region

The Productive Safety Net Programme (PSNP)

The Productive Safety Net Programme was launched in Ethiopia in 2005, with focus on vulnerable households in urban and rural areas as a first phase. After this, different phases were implemented by increasing its coverage from 4.5 million to over 7 million beneficiaries in 2012 and 8.3 million beneficiaries by 2015 [122].

The fourth phase of the Productive Safety Net Programme was implemented from 2016 to 2020. The programme was implemented in six regions of Ethiopia. The programme has a variety of support components: direct support, public work and livelihood support. The direct support beneficiaries are chronically food-insecure households that are unable to participate in public works, as well as orphans, pregnant and nursing mothers, people with disabilities, and the elderly. Public works involve labour-intensive activities to create community assets, such as the development of watersheds and climate change adjustment and mitigation. Livelihood support is designed to accelerate the exit or graduation of clients from the programme through technical support, community consultations and available resources and capabilities.

Sidama region (the former Sidama zone) is one of the areas where the Productive Safety Net Programme has been running since 2005, in highly vulnerable and drought-prone areas. The drought-prone areas in Sidama region include Boricha and Loko Abaya, which are located in the central Rift Valley region. In the rural Dale district of Sidama region, the programme is running in only a few kebeles; two of the seven kebeles included in our study.

The rationale for this thesis

Inequalities in most child and maternal healthcare services, including the nutritional aspect, are extensive between countries, regions and settings [88]. Reducing extreme poverty and hunger by the year 2025, and ending all forms of malnutrition by 2030, is a global target. However, most low-income countries, particularly those in the Horn of Africa, are far from achieving most of the targets [123]. Even though Ethiopia is achieving millennium development goal 4 by reducing child mortality, further strategies are needed to address targets related to nutrition [124].

A national survey data analysis has reported that the 24-hour consumption of eggs and flesh foods among children was 17.5% and 8.7%, respectively [125]. The report also documented large regional variations in animal-source food consumption among young children; the highest (41.7%) in Addis Ababa and the lowest (5.9%) in the Somali region. Likewise, animal-source food consumption is reported to be low among mothers in the reproductive age group and at the household level in Ethiopia [126-128].

Sidama region is one of the regions in Ethiopia where ensete is considered the main staple food. Ensete is also known for its poor content of protein, which is essential for normal child growth and good maternal nutrition. Despite its environmental benefits, ensete has limited benefits for children, particularly those under the age of two. Since the region also has a high prevalence of child and maternal undernutrition, dietary assessments will help to address the existing situation of young children and mothers in the area.

Even though minimal improvements are reported for some maternal and child health indicators, mothers and children in most rural areas of Ethiopia are still challenged. In addition to other health aspects, undernutrition among children and mothers remains a major public health problem. There is also limited information about mothers and children in rural areas, where home delivery is a common practice and postnatal service utilisation is very low; at 14% in the study area [56].

Objectives

General objective

The general objective of the study was to describe and analyse the dietary and non-dietary risk factors due to undernutrition among children younger than two and their mothers in the rural ensete-monoculture dominated Dale district, southern Ethiopia.

Specific objectives

1. To describe the nutritional status of and dietary practices for young children and to discuss the findings compared to studies made three to five decades ago, in the same area (Paper I).
    - To analyse the risk factor of faltering linear growth in the rural ensete-monoculture dominated Dale district, Sidama region of Ethiopia.
2. To analyse dietary and non-dietary factors associated with haemoglobin levels and BMI among mothers who gave birth in the past two years in the rural Dale district, Sidama region of Ethiopia (Paper II).
3. To analyse whether a household's livestock ownership influences animal-source food consumption frequencies among children and their mothers in rural areas (Paper III).

Methods and materials

Study location

This study was conducted in seven rural kebeles of the Dale district, which is located in the Sidama region, southern Ethiopia. A kebele is the smallest administrative unit in Ethiopia. Dale is one of 19 districts in the Sidama region. In 2017, the total population of the district was around 270,000 people, who were living in 36 rural and two urban kebeles. The main town of the district, Yirga Alem, is located 320 kilometres from Addis Ababa. In the Dale district, there are 33 health posts, 10 health centres and one hospital, the Yirga Alem general hospital. People living in these rural kebeles are mostly farmers. For centuries, ensete (*Ensete ventricosum*) has been a widely grown staple crop in the area. In recent years, maize has been introduced and adopted by most farmers. Other crops grown in the area include kale, cabbage and haricot beans. Coffee, chat (*Catha edulis*) and fruit like avocado, banana and mango are also grown and used as cash crops. The community also keeps livestock such as cows, goats, sheep and donkeys. The livestock mainly feed on ensete, and the animal manure is also used as a natural fertiliser in ensete cultivation.

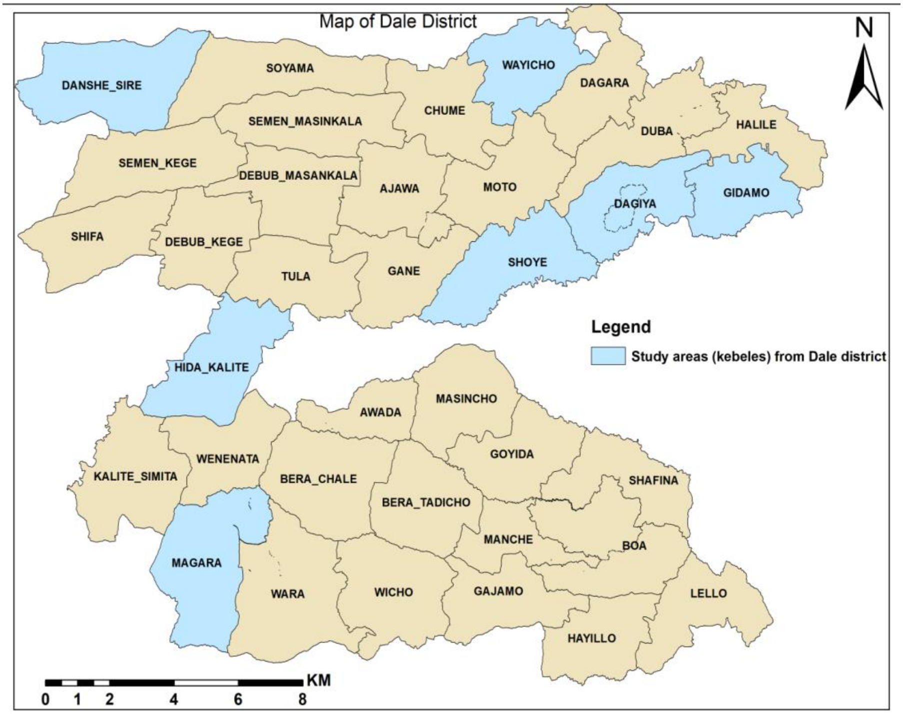

Figure 2: Map of Dale district with the study kebeles shaded in blue (the map is generated from the local coordinates taken by colleagues undertaking parallel research in the same area).

Study design and data

We used a community-based cross-sectional study design to assess the dietary practices and nutritional status of children below the age of two and their mothers. We obtained data on sociodemographic characteristics, anthropometry and haemoglobin, dietary information on child-mother pairs, and household characteristics.

Sample size estimation

The sample size was calculated using Open Epi version 3.01 (Dean AG, Sullivan Km, 2013) statistical software by assuming the proportion of 50%, 95% confidence level, 4% precision and 1.5 design effect. The Ethiopian demographic and health survey (2016) reported that the prevalence of stunting in southern Ethiopia was 39% [12] for children under the age of five. The proportion of mothers with a body mass index of <18.5kg/m^2 and anaemia was 22% and 24%, respectively, in the same national report. Our intention was to have the maximum sample size applicable for all papers; that is why a proportion of 50% was assumed. By adding a 10% non-response rate, the final sample size was set at 990 households with children under the age of two.

Table 1 below provides an overview of the selected participants from the cross-sectional study, and the data and analysis method used for the respective three papers. The details are explained below.

Table 1: Summary of papers with title, participants, data obtained and methods of analysis

Papers	Participants	Data	Analysis
Paper I Dietary practices and nutritional status of young children in the former ensete-monoculture dominated Sidama region, southern Ethiopia	Children aged 0-24 months	- Weight in kg - Length in cm - Haemoglobin level in g/dl - Sociodemographic characteristics of children and mothers - Maternal characteristics - Household background (household size, household food insecurity, wealth status) - 24 hour dietary recall	Descriptive analysis Multilevel linear regression
Paper II Anaemia, anthropometric undernutrition and associated factors among mothers with children younger than two years of age in the rural Dale district, southern Ethiopia	Mothers aged 15-49 and with a child under the age of two	- Weight in kg - Height in cm - Haemoglobin level in g/dl - Sociodemographic characteristics of mothers - Household background (household size, food insecurity, wealth status) - 24 hour dietary recall	Descriptive analysis Multilevel linear regression
Paper III Does livestock ownership contribute to the frequency of animal-source food consumption among children aged 6-24 months and mothers in Dale district, southern Ethiopia?	Child –mother pairs	- Animal-source food consumption frequency - Livestock ownership - Child and mother characteristics	Descriptive analysis Ordinal logistic regression

Outcome and exposure variables

The primary outcome variables in our study were: stunting and anaemia among children, underweight and anaemia among mothers, and animal-source food consumption frequencies among children and mothers, for the respective three papers. Prevalence of household food insecurity and prevalence of dietary diversity were also given.

Stunting was defined as a length-for-age z-score below minus-two standard deviations (< -2 SD) from the WHO child growth standard population mean [60], and assessed among children below the age of two using the child's weight and length measurements. Length-for-age (LAZ) is an expression of attained linear growth performance. Wasting was likewise defined as a weight-for-length z-score (WLZ) below minus two standard deviations (< -2 SD) from the WHO child growth standard population mean [60]. Underweight among mothers was defined as a body mass index (BMI) of less than 18.5 kg/m^2 and assessed by obtaining the mother's weight in kg and height in cm, which was later converted to metres.

Anaemia was defined as a haemoglobin level measurement below 11 g/dl for children and a haemoglobin level below 12.0 g/dl for mothers. Haemoglobin levels for children and mothers were assessed with capillary blood samples obtained by finger pricking and HemoCue HB 301 (Angelholm, Sweden) machines.

Exposure variables assessed in our study included household background information, sociodemographic characteristics and dietary information for children and mothers. Child characteristics included age of the child, gender of the child, birth order and place of birth, illness experience, weight and length. We also assessed the mother's characteristics such as age, age at first pregnancy, total number of pregnancies, use of family planning, weight, height and mid-upper arm circumference. The household background information included household size, data to calculate wealth index, and livestock ownership.

In this study, we assessed undernutrition and potential factors of relevance, as given in Table 2 below. Factors were identified based on UNICEF's conceptual framework and the existing research undertaken in the country. Table 2 displays similarities to and differences from the UNICEF framework.

Table 2: Potential exposure variables for child undernutrition addressed in our study, as compared with that of the UNICEF conceptual framework and variables

	UNICEF	Variables assessed in our study
Outcome	**Malnutrition**	**Stunting (linear growth restriction)**
Immediate causes	Inadequate dietary intake	Breastfeeding, dietary history, 24-hour dietary recall
	Diseases	Illness experience
Underlying causes	Inadequate access to food	Household food insecurity
	Inadequate care for children and women Inadequate education	Mother's education, Place of delivery and Immunisation,
	Insufficient healthcare and unhealthy environment	Housing conditions (number of rooms, building materials of major parts of the house), source of water, household size
Basic causes	Resource and control Human, economic and organisational resources	Wealth index
	Political and ideological factors Economic structure	
	Potential resources	

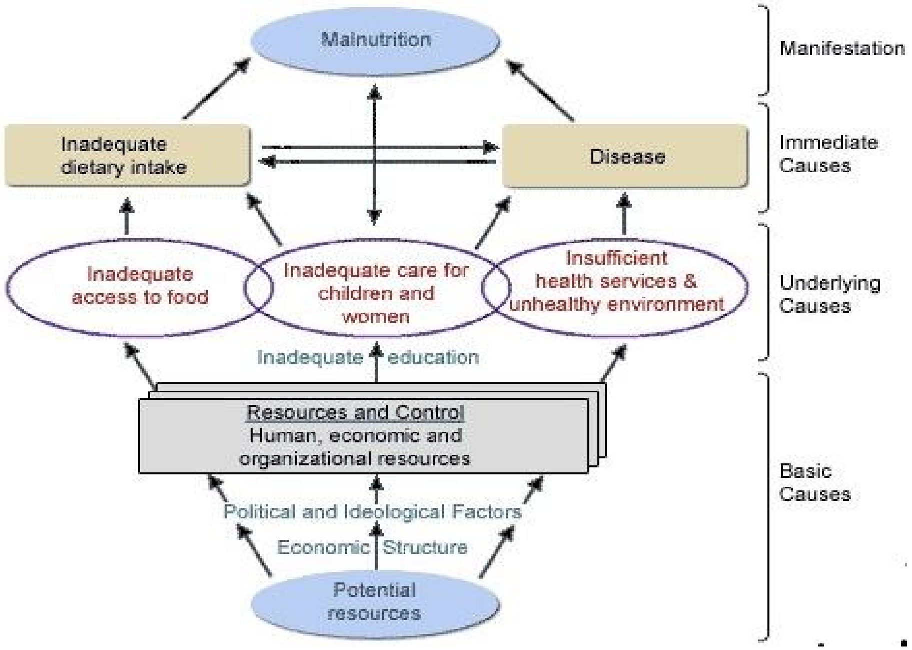

Figure 3: Conceptual framework of causes of child malnutrition, developed by UNICEF, 1991 [129].

Data collection

Face-to-face interviews by trained data collectors were used for the children's mothers and primary caregivers. All the data collectors and supervisors were fluent speakers of the local language, *Sidaamu Afoo*, which was used for data collection. All the questionnaires used were pre-tested in a similar setting, prior to the data collection. Translation and back translation of all the questionnaires were undertaken, to check consistency. Primary data was collected for all variables described in this thesis. Child immunisation cards were used to confirm the reported date of birth and age of the children. In the absence of immunisation cards, all the information was obtained from the respondent. Anthropometric measurements were made for each child and mother, following all the recommended procedures. Portable digital SECA weight scales were used to measure the weight of the children and mothers. While portable SECA stadiometers were used for the mothers' height, the UNICEF length boards were used to measure the recumbent length of the children. Mid-upper arm circumference was also measured using an MUAC measuring tape. Weight and length/height measurements were taken and recorded to the nearest 0.1 kg and 0.1 cm, respectively. HemoCue HB 301 machines were used to determine the capillary haemoglobin levels of children and mothers.

Statistical analysis

The data was double entered and validated with Epi data version 3.1, and then analysed using different software for different purposes. SPSS version 25 (IBM Corp, 2017) was used for descriptive analysis; STATA version 12 (Stata Corp LP, College Station, TX, 2011) was used to build multilevel regression models; ENA for SMART (Erhardt, Golden, and Seaman, 2011) was used to calculate child anthropometric indices; and principal component analysis (PCA) was used to construct the household's wealth index. Descriptive analysis was used to describe all variables in each specific paper. Multilevel linear regression analysis was used to explain association between the exposure and outcome variables (Paper I and Paper II). Ordinal logistic regression analysis was used to analyse the association between household livestock ownership and animal-source food computation (Paper III). The adjusted beta (β) coefficients (Papers I and II) and the adjusted Odds ratios (AOR) (Paper III) with the 95% confidence intervals (CI) were used to determine associations between the exposure and the outcome variables.

P-value < 0.25 (Papers I and II) and P-value < 0.20 (Paper III) in the bivariable regression were used as inclusion criteria for the multivariable regression. These cut-offs were used to avoid over-fitting and to improve model performance, as we collected a number of independent variables

[130, 131]. For the multivariable regression, P-value $\leq$ 0.05 and 95% confidence intervals were used to describe statistical significance.

Ethical considerations

Ethical clearance was obtained from Hawassa University, Ethiopia (Ref. No IRB/025/10 Date: 21/12/2017) and the Ethical Committee of Western Norway, Norway (Ref: 2017/90/REK, Date: 07/03/18). All the necessary official letters were obtained from the bodies concerned. Written consent was obtained from respondents and children's legal guardians, usually the mother and father. In the case of illiterate respondents, the data collector had to read the subject information and obtain a finger stamp when these respondents agreed to participate.

Results

The results of the three research papers are attached to this thesis and briefly summarised as follows:

Paper I: Undernutrition, dietary practices and risk factors of faltering linear growth among children aged 0-24 months

Paper I describes the dietary practices, household food insecurity and nutritional status of young children in Dale district, Sidama region, southern Ethiopia. We discuss our findings in the light of research of the same area three to five decades ago, and we analyse factors associated with the linear growth of young children. Children less than two years old and their primary caregivers (n=903) were included in this study. Among these, 791 children were aged above six months and 742 children out of 791 provided a 24-hour dietary recall. Linear growth failure (stunting) was prevalent among young children in the rural Sidama region and the majority of them were also anaemic. The prevalence of stunting, wasting and anaemia was 39.5%, 3.9% and 61.7%, respectively.

Older age, male gender, a lower haemoglobin level in children, and household food insecurity were risk factors for linear growth restriction in young children. For each month the child grew older, the length-for-age z-score decreased slightly (β -0.06; 95% confidence interval (CI): -0.07, -0.04). Boys were at greater risk of lower length-for-age z-scores than girls (β -0.05; 95% CI: -0.78, -0.27). Household food insecurity scores (β -0.05; 95% CI: -0.08, -0.01) and children's haemoglobin level (β 21; 95% CI: 0.06, 0.35) were also associated with length-for-age z-scores among young children.

Maize seems to be the dominant food in this previously ensete-dominated area. The majority of the children (97%) had eaten cereals (maize) during the past 24 hours, and 79.6% of households used maize as the main food. There have been minimal improvements in length-for-age z-score over the decades, but with a diet shift from ensete to maize.

Paper II: Anaemia and underweight among mothers who gave birth within the past two years

This paper assesses the haemoglobin levels and body mass index (BMI) of mothers with children below 2 years of age in a rural district of Sidama region, Ethiopia. It also analyses factors associated with low haemoglobin levels and with anthropometric undernutrition among mothers. Out of 931 mothers, 12.8% were anaemic and 12.6% had a BMI <18.5 kg/m^2. The prevalence of minimum dietary diversity was 37.8%. The majority (78.5%) of the households were food insecure. Weight (β 0.02; 95% CI: 0.003-0.03), dietary diversity scores (β 0.08; 95% CI: 0.03-0.12) and secondary school attendance (β 0.34; 95% CI: 0.08-0.59) were associated with improved haemoglobin level among mothers. Dietary diversity scores (β 0.08; 95% CI: 0.01-0.16) and household wealth (β 0.6; 95% CI: 0.27-0.94) were also associated with the mothers' BMI.

Paper III: Animal-source food consumption of children and mothers, and its association with livestock ownership

This paper describes animal-source food consumption among children aged 6-24 months and their mothers, and analyses its association with livestock ownership at household level. 851 child-mother pairs were included in the analysis. Nearly three quarters (74.1%) of the 851 households owned cows, and a quarter (213) kept goats or sheep. Dairy, egg and meat consumption among children in the past month was 91.8%, 83.0% and 26.2%, respectively. Likewise, the consumption of dairy, eggs and meat among mothers in the past month was 96.0%, 49.5%, and 34.0%, respectively. Dairy consumption frequency was 1.8 times higher among children (AOR=1.8, 95% CI: 1.3, 2.5) and three times higher among mothers (AOR=3.0, 95% CI: 2.2, 4.2) for households keeping cows, compared to households without cows. Egg consumption frequency was positively associated with hen and goat/sheep ownership for both children and mothers. However, meat consumption frequency among children was not associated with goat/sheep or hen ownership, and was negatively associated with cow ownership (AOR= 0.66, 95% CI: 0.45, 0.95), but positively associated with meat consumption for mothers. Dairy products were common animal-source foods consumed by children and mothers in the study area. On the other hand, meat consumption was low among children and mothers. Goat/sheep ownership was positively associated with most animal-source food consumption among children and mothers. Even though the majority of the households kept cows, this was negatively associated with meat consumption among young children. Hence, strategies to improve complementary feedings are warranted.

Discussion

The main aim of this thesis was to describe and analyse the nutrition situation of young children and mothers in the rural district of Sidama region, which is known for ensete monoculture. The thesis also assessed food insecurity and livestock ownership and their relevance to the nutritional status and dietary practices of children and mothers in the area. We observed a dietary shift whereby maize, instead of ensete, was the dominant staple used by children and mothers. Despite the dietary shift and efforts made in the area, only minimal improvement in the nutritional status of young children was observed, as compared with previous studies made in the area. We also observed that suboptimal dietary practices among children and mothers, chronic child undernutrition, and household food insecurity are still alarmingly high in the area. Below, we discuss the main findings of this thesis in the light of studies made in the area a few decades ago, as well as recent studies from different parts of the country and abroad.

Discussion of main findings

We found that the majority of the households in the study area used maize as a staple food. In our study, maize was used by around 80% of the households, and ensete was found to be less used in the diet; at nearly 20%. In the 1970s it was reported that ensete was the main staple food of the family, including young children [116]. However, in our study ensete was the second most common food for young children, next to maize. There is thus reason to believe that there has been a dietary shift from ensete to maize among the rural residents of the region. This dietary shift might be due to the adaptation of the newly introduced crop, maize, which is considered to be the modern approach [118]. Moreover, the cultivation of crops such as maize, coffee, chat and fruit might be an income-generating activity. Even though crop diversification is encouraged to improve dietary diversity and sustainability [132], it might lead to a progressive decline in ensete cultivation and higher vulnerability to droughts [118].

We also found that three fourths of the households in our study were food insecure. Although the older studies from the study area did not report household food insecurity, our finding was consistent with the recent studies from different regions of the country [133, 134]. This indicates that food insecurity is persistently high in most areas of Ethiopia. However, studies from some regions of Ethiopia have reported a relatively lower prevalence of food insecurity, at 39.7% [135] and 36.8% [136].

Regarding child feeding practices, 60% of the children were not getting the minimum dietary diversity. Early initiation of breastfeeding (within one hour of birth) and exclusive breastfeeding were practised for the majority of the children in our study. Although complementary feeding had started at the right time for most children, it was also delayed for 6% of them. This finding indicates that the practice of breastfeeding and the timing of complementary feeding were at an encouraging level. However, starchy staples: maize followed by ensete and tubers, constituted the diet of young children. This finding is supported by the finding of a study undertaken in southern Ethiopia [137]. Animal-source food intake was reported to be low; only 7.3% got flesh foods, which was similar to the 1970s [116]. Dairy products were the common animal-source foods used for young children, both in the previous studies and in ours. In our study, only 13% of the children consumed legumes and nuts in the 24-hour recall. This was supported by studies from another district in the region, which reported that optimal child feeding was 14.4% [109]. There is thus a need to promote protein-rich food intake using both animal and plant sources. Although no food taboos were reported in our study, the study in the 1970s had described the presence of food taboos [116]. A study from northern Ethiopia also reported that social norms and beliefs were common barriers to animal-source food consumption among young children [138]. An incomplete diet and lack of complementary feeding, especially flesh foods including fish, were thus, nutritional threats in the study area.

In our study, 39.5% of children below the age of two were stunted. The study from the 1990s referred to in Paper I evaluated the impact of seasonality on child nutrition [121]. We compared this with the report from July to December in the previous study; almost the same season as when our data was collected (August to November). The improvement in mean linear growth (LAZ score) was around half (0.6) compared to the aforementioned study in 1993. Even though we used WHO (2006) Growth Standards as a reference, WHO reference values from NCHS (1983) were used in the other study [121]. There are reasons to believe that for longitudinal growth impairment, the new standard corresponds to slightly higher values than in the old reference [139]. However, one can realise that there is a minimum improvement in child linear growth in this rural area during the period of more than two decades. The prevalence of stunting in our study was almost similar to the EDHS (2016) for the southern region [12]. However, our study subjects were children under the age of two from the rural area, while the EDHS report included children under the age of five from both urban and rural areas.

In our study, older child age, being male, lower haemoglobin levels of the child, and household food insecurity were associated with lower LAZ scores. The EDHS (2016) report documented that stunting had its peak at 24 months; similarly, our finding showed that older children up to the age of two were more affected by stunting. This finding supports that the time before the age of two is a critical period for preventing faltering linear growth. Being a boy was associated with a decrease in the length-for-age z-score by almost half, which is also supported by the EDHS (2016) report and other studies [140-142]. A study undertaken in four regions of Ethiopia also supports our finding; stunting is more common among male than among female children [122]. However, there are studies reporting no association between stunting and the child's gender [143, 144], and that boys are at lower risk than girls [15]. A study from Senegal documented that boys end exclusive breastfeeding earlier than girls during the recommended exclusive breastfeeding period of the first six months [145]. However, our study did not assess this and we suggest further studies to more deeply investigate the relation between gender and nutritional status among young children.

In our study, more than 60% of the children aged 0-24 months were anaemic. Our finding indicated that child anaemia was a major public health problem in our study area; greater than the national prevalence [12]. It was also shown that a child's haemoglobin level was positively associated with linear growth. Each unit increase in haemoglobin level was associated with an increase in LAZ score by 0.21. Other studies in India and Peru support our finding: a positive association between linear growth failure and low haemoglobin level [146]. We did not have the analytical laboratory capacity to address what proportion of the anaemia was nutritional anaemia. Our study also showed that an increase in household food insecurity score was associated with a decrease in LAZ score; where a higher t food insecurity score means that the household is more food insecure. A similar association was reported from a study in the Oromia region of Ethiopia [147]. Immediate action is needed to improve the situation whereby only a quarter of households were food secure. Maternal factors: age, height and haemoglobin did not show any association with child linear growth in our study, although maternal height was a risk factor in previous studies [148]. Moreover, more than one fourth of the children in our study were affected by both anaemia and stunting. A similar finding has recently been described in other child health studies from southern Ethiopia [82, 137], which suggests a need for similar preventive strategies for anaemia and stunting.

Regarding maternal dietary practice, we found that a majority of the mothers (62.4%) in our study had low dietary diversity. This finding was in line with a study in the Amhara region, northern Ethiopia, which reported that the inadequate dietary diversity among lactating mothers was 66% [149]. This finding indicates that nutritional interventions and dietary promotion should include lactating mothers. Our study also showed that 40% of the mothers had consumed fruit during the previous 24 hours. This proportion is low, as the area is among the fruit-producing areas of Ethiopia [150]. However, most fruits are seasonal and are mainly used for income-generation purposes [151].

In our study, a majority of the mothers (85%) had a BMI in the normal range (18.5 to 24.9 kg/m^2). We found a lower (12.6%) prevalence of underweight than reported in studies from northwestern Ethiopia (25%) [95] and the Afar region (33%) [152]. The difference may be due to the regional differences documented by other studies [153, 154]. These studies have found that mothers in the reproductive age group in southern Ethiopia were less likely to be underweight. The mean (SD) BMI in our study, 20.7 (2.0) kg/m^2, was higher than the mean (SD) BMI reported in the previous study in the area in the 1990s, at 18.9 (1.8) [121]. This may indicate an improvement in the nutritional status of mothers in the course of the two decades. Our finding also indicates a need for strategies to prevent obesity and to maintain normal BMI among mothers in the reproductive age group. The mean BMI in our study was the same as in the 2016 national EDHS report (20.7 kg/m^2) [12]. However, the prevalence of overweight in our study (2.5%) was lower than in the EDHS report (8%). The difference can be explained by the different scope and setting: a national survey compared to a study of a rural district. Labour-intensive activities and long-distance walks are more common among the rural residents than the urban counterparts. The risk of obesity may thus be lower in rural areas compared to the national report that also included urban residents. Another study from northwestern Ethiopia reported a prevalence of overweight (nearly 2%) that was similar to our finding [95].

We found a positive association between the dietary diversity score of the mother and her BMI. Our finding was in line with a study from another district in southern Ethiopia [155]. Unlike ours, however, the other study was performed in the town of the district. In addition, our findings showed that the household wealth index (the upper quartile) was positively associated with BMI. The aforementioned study from southern Ethiopia [155] also reported a positive association between wealth status and BMI. This association may be due to the fact that wealthier people can better afford more nutritious animal-source foods. However, this entails a need to promote a healthy lifestyle among wealthier people, who are in a food transition, to prevent overweight, obesity and the associated risk of non-communicable diseases [156, 157].

Anaemia among the mothers in our study was a mild public health problem, according to the WHO public health significance classification [2]. We have found that 12.8% of the mothers with children aged below two were anaemic. The prevalence of maternal anaemia in our study was lower than the national EDHS report in 2016 (24%) [12]. However, the EDHS, as a national report, included all women of reproductive age from urban and rural areas, while our study assessed mothers with children younger than two in rural areas. Compared to the mean haemoglobin level (12.4 g/dl) assessed during the immediate postpartum period in northwestern Ethiopia [158], our finding was higher. The difference can be explained by the time when the mother was assessed after delivery. In our study, mothers who had children below the age of two were included, and we excluded those who had given birth in the previous two months, while the other study assessed mothers immediately after delivery. The study setting, institutional in the other study, and community-based in our study, could also partly explain the difference. In addition, mothers in our study may be benefitting from the staple crop, ensete, which is a good source of iron [114, 159]. However, the prevalence of anaemia in our study was higher than found in Wolayita zone, southern Ethiopia (11%) [160]. The mean haemoglobin level reported in the study from Wolayita was also a little higher than ours (13.5g/dl compared with 13.2 g/dl). Hence, the haemoglobin levels reported in our study might show mothers' situation in terms of recent delivery and lactation [161]. Our finding indicates a need to promote maternal health services utilisation and strategies to prevent iron deficiency anaemia after delivery. While food fortification is a national-level approach to prevent micronutrient deficiency diseases, including anaemia [162], the access to, and utilisation of, fortified foods should be promoted. Differences in mean values and anaemia prevalence across studies must be interpreted with caution, as analytical factors may come into play.

In our study, the haemoglobin level of the mother was positively associated with dietary diversity, weight, and the educational status of the mother. Our findings showed a positive linear association between dietary diversity score and the mother's haemoglobin level. Similar positive associations were reported by studies in different parts of Ethiopia, including the eastern lowlands [163-165]. Secondary school attendance was positively associated with the haemoglobin level of the mothers in our study. This finding indicates that education is one of the factors that influence one's nutritional status in different ways; for example, educated people can have a higher income and be able to afford high-quality foods. Even though the mothers in our study were not employed, educated mothers may have more information, a better understanding and the creativity to help improve their income, nutritional status and health. We did not find any previous study in Ethiopia that evaluated the association between the weight and the haemoglobin status of mothers. However, our finding is in line with a study undertaken among rural Indian adolescent girls [166].

Despite the high prevalence of household food insecurity in our study, it was not associated with the haemoglobin level or BMI of the mother. The lack of association may be due to the fact that household food insecurity might not be a good indicator of micronutrient deficiency, as dietary diversity demonstrated in this study. In addition, people may respond 'no' to most of the HFIAS questions if they think that they have enough ensete or maize; they may not be aware of the risk of monotonous diets. This study also showed that the majority of the households reported that they had eaten a limited variety of food in the four weeks prior to this study. In addition, micronutrient deficiency conditions such as anaemia are related more to food quality than to food quantity.

In our study, animal-source food consumption among children and their mothers was generally low. Fifty six (6.6%) of the children and 19 (2.2%) of the mothers had never consumed animal-source foods during the past month. The consumption frequency of eggs and meat among children was higher than that of their mothers. Milk consumption among children was nearly double in households owning cows, compared to those that did not own cows. This finding is in line with studies that reported similar positive associations [167-169]. However, cow ownership was negatively associated with meat consumption among children. Considering that cows are kept mainly for milk production and not for meat, our finding is justifiable. However, other studies have reported that cow ownership is directly or indirectly associated with animal-source food consumption among young children [170]. Our finding may be due to traditional ways of livestock keeping [171] or a lack of local milk markets [172]. Even though milk and milk products are the main animal-source foods consumed by young children in the study area, further analysis of the quality of the milk used is required, as it is mostly diluted before use.

Households' ownership of goats/sheep and hens demonstrated a positive association with egg consumption among children. Egg consumption frequency among children from households owning hens was 3.5 times higher than among children from households without hens. This positive association was also reported by other studies [168, 173]. Our study showed that egg consumption among children is influenced directly and indirectly by keeping hens and goats/sheep, respectively. Goats/sheep are commonly kept for income generation purposes, which indirectly increases the household's ability to afford eggs from the local market. Similarly, households keep hens mainly for egg production, rather than poultry production, and they earn money from selling the eggs, or use the eggs to meet the household demand [127]. The relatively high milk consumption demonstrated in our study may also suggest that caregivers consider milk to be enough for young children and ignore other animal-source foods, particularly meat. In addition, food taboos concerning meat and poultry consumption by young children might be present [174].

Mothers who had consumed meat during the past month accounted for 34%, which was lower than reported by a study undertaken in Gondar town, northwestern Ethiopia [175]. This difference may be explained by the differences in dietary practices among mothers, especially after delivery. The study settings can provide an additional explanation: rural and community-based in our study, compared to urban (Gondar town) and facility-based in the other study. On the other hand, meat consumption among mothers in our study was higher than in a study from the Afar region, in which this was reported at 11% among lactating mothers [176]. Goat/sheep and hen ownership also demonstrated a positive association with mothers' meat consumption. Likewise, hen ownership was associated with meat consumption among mothers (adults), but not among children. As we discussed above, this indicates that feeding poultry to children may not be culturally accepted.

Even though eggs were mainly given to children (83%), around 50% of the mothers had consumed eggs during the past month. Keeping hens was also positively associated with egg consumption among mothers. This finding can explain the indirect positive association of goat/sheep keeping, which increases the purchasing ability of the household [177]. More than 95% of the mothers had consumed dairy products during the past month. In most rural areas the watery portion of the milk after fat extraction is used. Otherwise, whole milk is rarely used to meet household demand. In our study, mothers who kept cows consumed dairy products 1.9 times more frequently than those who did not. A similar association was reported in studies undertaken in Ethiopia [127, 178] and in the study from Kenya [179]. In general, our finding indicates that keeping cows entails positive exposure to dairy product consumption among rural households. Goat/sheep ownership was also positively associated with the mothers' milk consumption frequency. This association can be explained in two ways: through purchasing milk from the local market after selling live goat/sheep, and by using goat's milk. There is a study reported on the utilisation of goat's milk in Ethiopia [180].

Discussion of methods

To assess the validity of the findings, strengths and limitations of methods employed from the research design to the analysis stage need to be discussed. Below, I discuss some methodological issues and how these may have affected the validity of this study.

Study design

Quantitative research designs are generally categorised as observational and experimental, where cohort studies, case-control studies and cross-sectional studies belong to the former category. Intervention studies or clinical trials fall into the category of experimental studies, where the investigator is meant to randomly assign the exposure status. Ideally, in well-designed trials, the groups should be similar, so as to rule out other factors to explain the relationship found between exposure and control. While it might sometimes not be feasible to conduct experimental studies, observational studies may give an opportunity for certain research questions to be answered. In addition, well-designed observational studies might answer different research questions, compared to trials and therefore, observational studies have their own worth [181].

This cross-sectional thesis study was conducted (Papers I-III) to describe the dietary practices and the nutritional situations of children and mothers. We used measurements to describe the prevalence of different forms of undernutrition (stunting and anaemia among children, and underweight and anaemia among mothers). We also used analytical approaches to determine associations between potential exposure variables and outcome variables (undernutrition among children and mothers).

In cross-sectional studies, the exposure and the outcome factors are collected at the same time, thus it does not determine the causative and temporal relationship between exposure and outcome variables, which is called reverse causality. The benefit of cross-sectional studies would be related to feasibility and flexibility. The design was thus appropriate to answer the study questions of this thesis, which were largely observational and analytical in nature.

Bias

Bias is systematic error that occurs in any study, at any stage of the study. Systematic error (bias) is a tendency to underestimate or overestimate the value of interest and compromises the validity of a study [182]. In the sections below three types of bias are discussed in relation to this thesis.

Selection bias

Some eligible households with children and mothers left their kebele after they were randomly selected, and were replaced with eligible children and mothers from the same kebele. This may have caused some 'healthy participant' selection bias. For Paper I, we included children aged 0 to 24 months to describe nutritional status and background characteristics. A total of 82 children (8% of the estimated study size) were excluded from analysis. Exclusion due to uncertain age took place before analysis for Paper 1, in order to avoid problems in determining anthropometric status, particularly HAZ, which is age dependent. This number was large and most likely due to the practice of home deliveries and limited routines for recording date of birth. In Paper II, we analysed 95% of the total sample. The rest were excluded due to not being a biological mother (as we considered child-mother pairs), current pregnancy, and missing data on the outcome variable. This may also have introduced analytical selection bias. In Paper III, we included 851 child-mother pairs to determine animal-source food consumption frequencies among young children and their mothers. Children aged 6-24 months paired with their mothers were included. The sample size was thus smaller for this paper and was not considered in the original sample size calculation.

We assessed selection bias at different levels. We used mapping and listing to ensure a random representation of participants from a geographically predetermined area. We thus assume that there is most risk of selection bias for the replacements made. However, replacements were made in order to ensure fulfilment of the sample size. We consider the sample size to be robust by using 50% proportion, 80% power and 10% non-response rate during sample size estimation. Post-hoc power analysis took place for models at risk of type II errors; those with a statistical finding not being significant where one cannot tell if there is no association, or that the association is not shown due to too low power and precision to detect it. GPower V.3.1 was used to estimate post-hoc power for linear regression in Papers I and II and OpenEpi V.3.01 was used for logistic regression in Paper III. In Paper I and Paper II, the post-hoc power analysis was mostly above 80%. In Paper III, it was similar, except for a few models, including for hen ownership and cow ownership, where the power was very low (16% and 54%, respectively). I acknowledge that post-hoc power calculations also have limitations. First, the sample size is already set according to a rationale. Absence of an association should not be anticipated as a power problem, as large sample size may detect associations of limited public health and clinical relevance [183]. One should therefore also consider whether differences or associations found are large and relevant. With multiple analytical models one also runs the risk of type I errors; that a finding, by chance, is found to be associated. This is also an argument in favour of working according to pre-determined research questions and study designs.

Information bias

Information bias is a systematic error introduced by the observer or the respondent. Our study was also prone to recall bias, since we used interviews requiring the respondent to have a good memory. Dietary recall is particularly vulnerable to recall bias [184]. However, we applied techniques such as designing questions in multiple ways, so that the information obtained was cross-checked. For instance, we obtained the birth date of the child and we calculated the child's age for comparison with the age reported by the mother. We also cross-checked birth dates with documents such as immunisation cards, if available. Some local and national events were also used to facilitate the memory of the respondents. Repeating and clarifying questions as necessary was an additional strategy used.

Measurement bias

Measurement bias is another systematic bias caused by the measuring instrument or the observer [182]. Our study involved measurements of length, height, weight and mid-upper arm circumference, as well as rapid diagnostic tests, which may cause measurement errors. To minimise measurement bias in our study, we applied techniques such as repeating measurements twice for length, weigh and mid-upper arm circumference. Practical training was given to data collectors and supervisors on the procedure for each measurement. Daily cleaning and calibration of measuring instruments were also practised.

Confounding and effect modification

Confounding is the presence of a third variable associated with the exposure and the outcome, and affects the actual relationship between the exposure and the outcome [185]. Confounding is a problem in most observational studies. At the design stage, the researcher needs to identify potential confounding factors that can be assessed at the analytical stage. The usual technique is to check whether the association identified between exposure and outcome is changed on adjusting for a factor in the regression model. Effect modification or interaction refers to a situation in which the effect of one variable on another varies across the strata of a third variable [186, 187]. The effect modifier thus lies in the causal pathway between the exposure and the outcome. During the analysis stage, effect modifiers can be controlled by stratification; performing the analysis for the various strata of the exposure variable. In addition, during data analysis we used bivariable and multivariable regression analysis and stratified different exposure variables. Despite these efforts we cannot rule out other potential confounders or residual confounders for the associations described.

Causation

A principal aim of epidemiology is to assess the causes of disease that can be established by conducting experiments. However, most epidemiological studies are observational and at best may describe risks or composite causes. The association found may describe an actual relationship, an inference, or may also be due to chance (random error), bias (systematic error) or confounders [188]. Associations in observational studies could also be evaluated according to the nine Bradford Hill criteria [189]. However, Rothman has argued that some of the Bradford Hill criteria are misleading [186]. Nevertheless, even if not ideal, this study met some criteria for the key findings.

Hill's criteria

The first criterion relates to the strength of the association. Assessing an association as large is not always meaningful. However, an odds ratio expresses the odds of an outcome occurring, given the presence of the outcome, compared to the odds of it occurring, given the absence of the exposure [190]. An odds ratio of e.g. two indicates doubled odds of such an outcome. Associations of cow ownership with dairy consumption (AOR 1.8; 95% CI: 1.3, 2.5) and hen ownership with egg consumption among children (AOR 3.5; 95% CI: 2.6, 4.8) were examples of strong association. The strength of the association does not consider the frequency of outcome or the absolute effect, and thus the description of it as large may not determine its relevance.

Furthermore, Bradford Hill list consistency of findings, meaning that the same findings are observed among different populations, using different study designs and at different times. For our study, this was largely present and is discussed for the individual papers. Whether the next criterion of specificity is relevant can be discussed, however. Specificity implies that there is a one-to-one relationship between the exposure and the outcome. Specificity is an arguable criterion since an effect may have more than one cause and an exposure may have more than one effect [186]. In this thesis, we saw that multiple exposures, including poverty, low education and poor nutrition, led to various nutritional and health problems in the mother and the child. Similarly, a cross-sectional study cannot assess any temporal relationship, although it is highly likely that poverty precedes undernutrition, but intergenerational undernutrition may also precede poverty. For instance, anaemia may affect working capacity directly [191].

The dose-response relationship could to some extent be assessed in a cross-sectional study. We saw a positive association between the dietary diversity score of mothers and their haemoglobin levels (Paper II). This implies that when the dietary diversity score of a mother increased by 1, the haemoglobin level increased by 0.08g/dl (adjusted β 0.08; 95% CI: 0.03, 0.12). A lot of the findings were plausible from both a biological and public health perspective. An obvious example was the association between wealth index and mother's BMI; as wealth could lead to improved diet, this improved weight. Two of the latter criteria, coherence and analogy, were generally met, as our findings largely agreed with current knowledge and have been seen elsewhere.

External validity

External validity refers to the generalizability of research findings outside the study area [192, 193]. External validity largely depends on the internal validity of the study. Our study was conducted in a typical rural area known for ensete monoculture, and different measures were taken to minimise bias and maintain internal validity. We therefore believe that our findings are applicable in areas sharing similar characteristics with our study area.

Ethical considerations

Ethical clearance was obtained from Hawassa University, Ethiopia and the Ethical Committee of Western Norway, Norway. Official letters were obtained from all bodies concerned at regional, district and kebele levels. Written informed consent was obtained from respondents and legal guardians of children. The data is kept with care to maintain confidentiality and no identifiers were used to communicate findings. The study was carried out as planned and followed all applicable standards and principles of the World Medical Association Declaration of Helsinki, 2013 [194].

Strengths and limitations

This thesis has a set of strengths and also limitations, which described below.

Strengths

Our study had strengths as a community-based study using a random sampling technique. The sampling framework was prepared as a baseline survey conducted prior to the main data collection. All the data collectors and supervisors were fluent speakers of the local language, *Sidaamu Afoo*, which was used for the interviews. Simulated practical training was included in the training sessions for data collectors and supervisors. Collecting a comprehensive set of data concerning young children, mothers and households through interviews, measurements and rapid field tests was also strength of our study. Moreover, assessing the food frequency for one month's duration helps to address food items with infrequent consumption among children and mothers. The application of multilevel data analysis is an additional strength of our study, accounting for clustering effect.

Limitations

The presence of potential bias (selection, recall and survivor bias), as discussed above, may impose limitations on this thesis. The fact that we have no data from the local health facilities concerning women's health service coverage may be considered a limitation. However we cited recent studies from the same area, which addressed issues related to health utilisation and coverage. We did not assess portion size when assessing food consumption, nor the number of each type of livestock and to whom they belonged (the mother or the father), which is also a limitation. There may also be residual confounding that is not particularly addressed, including long-term morbidity patterns, such as parasites and immune deficiency.

Conclusions

The following conclusions are made based on our findings in relation to each of the specific objectives of this thesis.

Objective 1

To describe the nutritional status and dietary practices of young children compared with studies made three to five decades ago in the same area (Paper I).

Conclusion 1: There is a high burden of chronic child undernutrition and, compared to the older studies from the area, there have been limited improvements in the course of the decades.

Conclusion 2: Changes in the community's food system were demonstrated, whereby the cultivation and utilisation of ensete is gradually being replaced by maize. The description 'monoculture dominated' may not fit the existing situation of the area, even though further assessment to address seasonal variations is warranted.

Objective 2

To analyse the risk factors for faltering linear growth in the rural ensete-monoculture dominated Dale district, Sidama region of Ethiopia (Paper I).

Conclusion 1: Child age, gender and haemoglobin level of the child, as well as household food insecurity score, are important child and household-related factors associated with linear growth or stunting.

Conclusion 2: Household food insecurity was experienced by the majority of households and showed positive association with undernutrition among children.

Objective 3:

To analyse dietary and non-dietary factors associated with haemoglobin levels and BMI among mothers who had given birth in the past two years in the rural Dale district, Sidama region of Ethiopia (Paper II).

Conclusion 1: Anaemia and underweight among mothers who had a child aged less than two did not constitute major problems in our study area, according to the WHO public health significance classification.

Conclusion 2: The majority of the mothers had low dietary diversity, which was a single factor independently associated with undernutrition among mothers.

Objective 4:

To analyse whether livestock ownership influences animal-source food consumption frequencies among children and their mothers in rural areas? (Paper III)

Conclusion 1: Animal-source food consumption, particularly meat and fish consumption are generally low and almost null, respectively, among mothers and children.

Conclusion 2: Livestock ownership was an important factor contributing to animal-source food consumption among young children and mothers in rural settings.

General recommendations

1. There is a need to strengthen efforts to improve household food security, and young children's complementary diet, with considerable focus in rural districts, while monitoring growth, diet and health in young children.
2. Promoting the environmental benefits of ensete and availing of modern technologies for ensete cultivation and processing can be a strategic approach in line with the promotion of diversified crop cultivation.
3. Education and promotion of minimum dietary diversity among children and mothers may help to improve nutritional status and reduce vulnerability to deficiency diseases.
4. Strengthening the existing nutrition interventions such as the Productive Safety Net Programme help to ensure food access for rural households. Moreover, designing new strategies such as small-scale fish farming at community level can help rural households to access nutritious foods.
5. Livestock keeping should be promoted, primarily for household demand to facilitate animal-source food consumption.
6. Multi-sector collaboration needs to be ensured, to address the health, nutrition and education aspect of the community as whole.

Recommendations for future research

We recommend that future studies consider local health service utilisation, so as to closely address strategies to prevent anaemia among mothers during pregnancy and after delivery. Evaluation of conditions that may contribute to undernutrition, such as intestinal parasites and immune-suppressive conditions are better to be considered. We also recommend further research of food taboos in this rural area, particularly among mothers and young children. In addition, interventional studies to check the feasibility and effectiveness of some of the recommendations need to be conducted.

References

1. World Health Organization, Global anaemia reduction efforts among women of reproductive age: impact, achievement of targets and the way forward for optimizing efforts. Geneva: World Health Organization, 2020.
2. World Health Organization, Nutrition Landscape Information System (NLIS) country profile indicators: interpretation guide, second edition. Geneva: World Health Organization, 2019.
3. Victora, C.G., et al., Revisiting maternal and child undernutrition in low-income and middle-income countries: variable progress towards an unfinished agenda. Lancet, 2021. **397**(10282): p. 1388-1399. https://doi.org/10.1016/S0140-6736(21)00394-9
4. McDonald, C.M., et al., The effect of multiple anthropometric deficits on child mortality: meta-analysis of individual data in 10 prospective studies from developing countries. The American Journal of Clinical Nutrition, 2013. **97**(4): p. 896-901. https://doi.org/10.3945/ajcn.112.047639
5. Martorell, R. and A. Zongrone, Intergenerational influences on child growth and undernutrition. Paediatric and perinatal epidemiology, 2012. **26**: p. 302-314. https://doi.org/10.1111/j.1365-3016.2012.01298.x
6. Watson, D., et al., Community perspectives on maternal and child health during nutrition and economic transition in sub-Saharan Africa. Public Health Nutrition, 2020. **24**(12): p. 3710-3718. https://doi.org/10.1017/S1368980020003018
7. Quamme, S.H. and P.O. Iversen, Prevalence of child stunting in Sub-Saharan Africa and its risk factors. Clinical Nutrition Open Science, 2022. https://doi.org/10.1016/j.nutos.2022.01.009
8. Davis, J.N., B.M. Oaks, and R. Engle-Stone, The Double Burden of Malnutrition: A Systematic Review of Operational Definitions. Current Developments in Nutrition, 2020. **4**(9). https://doi.org/10.1093/cdn/nzaa127
9. Amugsi, D.A., Z.T. Dimbuene, and C. Kyobutungi, Correlates of the double burden of malnutrition among women: an analysis of cross sectional survey data from sub-Saharan Africa. BMJ Open, 2019. **9**(7): p. e029545. https://doi.org/10.1136/bmjopen-2019-029545
10. Hasan, M.M., et al., Double Burden of Malnutrition Among Women of Reproductive Age in Low- and Middle-Income Countries: Progress Achieved and Opportunities for Meeting the Global Target. Current Developments in Nutrition, 2020. **4**(Supplement_2): p. 839-839. https://academic.oup.com/cdn/article/4/Supplement_2/839/5845133
11. Mekuria, W., The link between agricultural production and population dynamics in Ethiopia: a review. Adv. Plants Agric. Res, 2018. **8**(2): p. 348-353. https://doi.org./10.15406/apar.2018.08.00336
12. Central Statistical Agency (CSA) [Ethiopia] and ICF, Ethiopia Demographic and Health Survey 2016: Key Indicators Report., Addis Ababa. Ethiopia, and Rockville, Maryland, USA. CSA and ICF.
13. Darebo, T., A. Mesfin, and S. Gebremedhin, Prevalence and factors associated with overweight and obesity among adults in Hawassa city, southern Ethiopia: a community based cross-sectional study. BMC obesity, 2019. **6**(1): p. 1-10.

14. Omer, I., T. Derese, and Y. Sintayehu, Overweight and Its Associated Factors among Women of Reproductive Age in Dire Dawa, Eastern Ethiopia, 2021: Community-Based Cross-Sectional Study. Journal of Obesity, 2022. **2022**. https://doi.org/10.1155/2022/7268573
15. Abeway, S., et al., Stunting and its determinants among children aged 6–59 months in northern Ethiopia: a cross-sectional study. Journal of nutrition and metabolism, 2018. https://doi.org/10.1155/2018/1078480
16. Gebremichael, B., et al., Undernutrition and associated factors among rural pregnant women in Eastern Ethiopia. SAGE Open Medicine, 2022. https://doi.org/10.1177/20503121221104430
17. Webb, P., et al., Hunger and malnutrition in the 21st century. BMJ, 2018. **361**. http://dx.doi.org/10.1136/bmj.k2238,
18. Soliman, A., et al., Early and long-term consequences of nutritional stunting: from childhood to adulthood. Acta Biomed, 2021. **92**(1). https://doi.org/10.23750/abm.v92i1.11346
19. Popkin, B.M., C. Corvalan, and L.M. Grummer-Strawn, Dynamics of the double burden of malnutrition and the changing nutrition reality. The Lancet, 2020. **395**(10217): p. 65-74. https://doi.org/10.1016/S0140-6736(19)32497-3
20. Christopher J. Bates, B.B.a.B.H., Nutritional Assessement Methods, in Human nutrition. 2017. p. 613-646. https://www.researchgate.net/publication/318779321
21. Khanna, D., et al., Body Mass Index (BMI): A Screening Tool Analysis. Cureus, 2022. **14**(2): e22119. https://doi.org/10.7759/cureus.22119
22. Welch, A.A., Dietary intake measurement: Methodology, in Encyclopedia of Human Nutrition (Third Edition), B. Caballero, Editor. 2013, Academic Press: Waltham. p. 65-73. http://dx.doi.org/10.1016/B978-0-12-375083-9.00075-1
23. Smith, L.O., et al., Clinical Applications of Body Composition and Functional Status Tools for Nutritional Assessment of Hospitalized Adults: A Systematic Review. Journal of Parenteral and Enteral Nutrition, 2022. https://doi.org/10.1002/jpen.2444
24. Hebestreit, A., et al., Web-based 24-h dietary recall: the SACANA program, in Instruments for health surveys in children and adolescents. 2018, Springer. p. 77-102. https://doi.org/10.1007/978-3-319-98857-3_5
25. Naaman, R., et al., Assessment of dietary intake using food photography and video recording in free-living young adults: a comparative study. Journal of the Academy of Nutrition and Dietetics, 2021. **121**(4): p. 749-761. https://doi.org/10.1016/j.jand.2020.09.040
26. El Kinany, K. and V. Garcia-Larsen, Adaptation and validation of a food frequency questionnaire (FFQ) to assess dietary intake in Moroccan adults. 2018. **17**(1): p. 61.
27. Kinshella, M.-L.W., S.E. Moore, and R. Elango, The missing focus on women's health in the First 1,000 days approach to nutrition. Public Health Nutrition, 2020. **24**(6): p. 1526-1530. https://doi.org/10.1017/S1368980020003894
28. Teshale, A.B., et al., Anemia and its associated factors among women of reproductive age in eastern Africa: A multilevel mixed-effects generalized linear model. 2020. **15**(9): p. e0238957. https://doi.org/10.1371/journal. pone.0238957

29. McLean, E., et al., Worldwide prevalence of anaemia, WHO Vitamin and Mineral Nutrition Information System, 1993–2005. Public Health Nutrition, 2009. **12**(4): p. 444-454. https://doi.org/10.1017/S1368980008002401
30. Smith-Greenaway, E., et al., Global burden of maternal bereavement: indicators of the cumulative prevalence of child loss. BMJ Glob Health, 2021. **6**(4). https://doi.org/10.1136/bmjgh-2020-004837
31. Ritchie, H. and M. Roser, Micronutrient deficiency. Our World in data, 2017. https://ourworldindata.org/micronutrient-deficiency
32. Ogunbode, O. and O. Ogunbode, Anaemia in pregnancy, in Contemporary obstetrics and gynecology for developing countries. 2021, Springer. p. 321-330. https://doi.org/10.1007/978-3-030-75385-6_29
33. Warner, M.J. and M.T. Kamran, Iron deficiency anemia. 2017. PMID: 28846348
34. Lanzkowsky, P., Iron-deficiency anemia, in Lanzkowsky's Manual of Pediatric Hematology and Oncology. 2016, Elsevier. p. 69-83. http://dx.doi.org/10.1016/B978-0-12-801368-7.00002-8
35. World Health Organization, Haemoglobin Concentrations for the Diagnosis of Anaemia and Assessment of Severity. Vitamin and Mineral Nutrition Information System Geneva, World Health Organization (WHO/NMH/NHD/MNM/11.1); 2011. http://www.who.int/vmnis/indicators/haemoglobin.Pdf
36. Jullien, S., Screening of iron deficiency anaemia in early childhood. BMC pediatrics, 2021. **21**(1): p. 1-6. https://doi.org/10.1186/s12887-021-02725-w
37. Rappaport, A.I., et al., Variability in haemoglobin concentration by measurement tool and blood source: an analysis from seven countries. Journal of Clinical Pathology, 2020. **74**(10): p. 657-663. https://doi.org/10.1136/jclinpath-2020-206717
38. Adam, I., et al., Comparison of HemoCue® hemoglobin-meter and automated hematology analyzer in measurement of hemoglobin levels in pregnant women at Khartoum hospital, Sudan. Diagnostic Pathology, 2012. **7**(1): p. 1-6. https://doi.org/10.1186/1746-1596-7-30
39. Pasricha, S.R., et al., Iron deficiency. Lancet, 2021. **397**(10270): p. 233-248. https://doi.org/10.1016/S0140-6736(20)32594-0
40. James, P.T., et al., Women's nutrition: A summary of evidence, policy and practice including adolescent and maternal life stages. Emergency Nutrition Network (ENN): Kidlington, Oxford, UK, 2021.
41. Means, R.T., Iron Deficiency and Iron Deficiency Anemia: Implications and Impact in Pregnancy, Fetal Development, and Early Childhood Parameters. Nutrients, 2020. **12**(2). https://doi.org/10.3390/nu12020447
42. World Health Oranization, Antenatal care recommendations for a positive pregnancy experience. Nutritional interventions update: Multiple micronutrient supplements during pregnancy. Geneva: World Health Organization; 2020.
43. Hemler, E., W. Fawzi, and S. Wrottesley, Current evidence on anaemia and micronutrient supplementation strategies in school-age children and adolescents. Field Exchange 66, 2022: p. 66.
44. Keats, E.C., et al., Effective interventions to address maternal and child malnutrition: an update of the evidence. Lancet Child Adolescent Health, 2021. **5**(5): p. 367-384. https://doi.org/10.1016/S2352-4642(20)30274-1

45. Hall, A.G., et al., An Animal-Source Food Supplement Increases Micronutrient Intakes and Iron Status among Reproductive-Age Women in Rural Vietnam. Journal of Nutr, 2017. **147**(6): p. 1200-1207. https://doi.org/10.3945/jn.116.241968
46. Olson, R., et al., Food Fortification: The Advantages, Disadvantages and Lessons from Sight and Life Programs. Nutrients, 2021. **13**(4): p. 1118. https://doi.org/10.3390/nu13041118
47. McCarthy, E.K., D.M. Murray, and M.E. Kiely, Iron deficiency during the first 1000 days of life: are we doing enough to protect the developing brain? 2022. **81**(1): p. 108-118. https://doi.org/10.1017/S0029665121002858
48. Martorell, R., Improved nutrition in the first 1000 days and adult human capital and health. American Journal of Human Biology, 2017. **29**(2): p. e22952. https://doi.org/10.1002/ajhb.22952
49. Dipasquale, V., U. Cucinotta, and C. Romano, Acute malnutrition in children: pathophysiology, clinical effects and treatment. Nutrients, 2020. **12**(8): p. 2413. https://doi.org/10.3390/nu12082413
50. World Health Organization, and United Nations Children's Fund (UNICEF , Indicators for assessing infant and young child feeding practices: Definitions and measurement methods. World Health Organization,2021. https://apps.who.int/iris/handle/10665/340706
51. Masuke, R., et al., Effect of inappropriate complementary feeding practices on the nutritional status of children aged 6-24 months in urban Moshi, Northern Tanzania: Cohort study. PloS one, 2021. **16**(5): p. e0250562. https://doi.org/10.1371/journal.pone.0250562
52. Sundararajan, S. and H. Rabe, Prevention of iron deficiency anemia in infants and toddlers. Pediatric Research, 2021. **89**(1): p. 63-73. https://doi.org/10.1038/s41390-020-0907-5
53. Kurpad, A.V. and H.S. Sachdev, Commentary: Time for precision in iron supplementation in children. International Journal of Epidemiology, 2022. **51**(5): p. 1543-1545. https://doi.org/10.1093/ije/dyac102
54. World Health Organization, The global prevalence of anaemia in 2011. Geneva: World Health Organization, 2015.
55. Feleke, B.E. and T.E. Feleke, Pregnant mothers are more anemic than lactating mothers, a comparative cross-sectional study, Bahir Dar, Ethiopia. BMC hematology, 2018. **18**(1): p. 1-7. https://doi.org/10.1186/s12878-018-0096-1
56. Areru, H.A., et al., Low and unequal use of outpatient health services in public primary health care facilities in southern Ethiopia: A facility-based cross-sectional study. BMC health services research, 2021. **21**(1): p. 1-14. https://doi.org/10.1186/s12913-021-06846-x
57. Gebreegziabher, T., et al., Chronic inflammation was a major predictor and determinant factor of anemia in lactating women in Sidama zone southern Ethiopia: A cross-sectional study. PLoS One, 2020. **15**(10): p. e0240254. https://doi.org/10.1371/journal.pone.0240254
58. Ethiopian Public Health Institute (EPHI) and ICF. Ethiopia Demographic and Health Survey 2019: Final report. Rockville, Maryland, USA: EPHI and ICF, 2019.
59. Egata, G., et al., Seasonal variation in the prevalence of acute undernutrition among children under five years of age in east rural Ethiopia: A longitudinal study. BMC Public Health, 2013. **13**(1): p. 1-8. http://www.biomedcentral.com/1471-2458/13/864

60. World Health Organization, Child Growth Standards based on length/height, weight and age, in Acta paediatrics (Oslo, Norway: 1992). Supplement. 2006. p. 76.
61. World Health Organization, Child growth standards and the identification of severe acute malnutrition in infants and children: joint statement by the World Health Organization and the United Nations Children's Fund. 2009.
62. Wells, J.C., et al., Beyond wasted and stunted—a major shift to fight child undernutrition. The Lancet Child & Adolescent Health, 2019. **3**(11): p. 831-834. http://dx.doi.org/10.1016/S2352-4642(19)30244-5
63. Demilew, Y.M. and A.T. Alem, Food security is not the only solution to prevent under-nutrition among 6-59 months old children in Western Amhara region, Ethiopia. BMC pediatrics, 2019. **19**(1): p. 1-9. https://doi.org/10.1186/s12887-018-1386-2.
64. Hong, R., J.E. Banta, and J.A. Betancourt, Relationship between household wealth inequality and chronic childhood under-nutrition in Bangladesh. International Journal for Equity in Health, 2006. **5**(1): p. 15. https://doi.org/10.1186/1475-9276-5-15
65. Cliffer, I.R., et al., Linear Growth Spurts are Preceded by Higher Weight Gain Velocity and Followed by Weight Slowdowns Among Rural Children in Burkina Faso: A Longitudinal Study. The Journal of Nutrition, 2022. **152**(8): p. 1963-1973. https://doi.org/10.1093/jn/nxac071
66. Briend, A., The complex relationship between wasting and stunting. American Journal of Clinical Nutrition, 2019. **110**(2): p. 271-272. https://doi.org/10.1093/ajcn/nqz050
67. Sessions, N. and T. Khara, The Wasting-Stunting Technical Interest Group: A summary of the work to date. Field Exchange 67, 2022: p. 51.
68. Subramanian, S., O. Karlsson, and R. Kim, Using height-adjusted stunting prevalence will fail disadvantaged children worldwide. The Lancet Global Health, 2022. **10**(5): p. e621.
69. Ray, S., Relationship between stunting and wasting in children. Medical journal, Armed Forces India, 2013. **69**(4): p. 410. http://dx.doi.org/10.1016/j.mjafi.2012.10.004
70. Kraemer, K., Making stunting a development indicator. Sight Life, 2016. **30**(1): p. 10-2.
71. Vaivada, T., et al., Stunting in childhood: an overview of global burden, trends, determinants, and drivers of decline. American Journal of Clinical Nutrition, 2020. **112**(Suppl 2): p. 777s-791s. https://doi.org/10.1093/ajcn/nqaa159
72. Onis, M. and F. Branca, Childhood stunting: a global perspective. Maternal & child nutrition, 2016. **12**(S1): p. 12-26. https://doi.org/10.1111/mcn.12231
73. Feyisa, B.B., et al., Feeding practice, energy, and nutrient intake adequacy among children aged 6–23 months in Southern Ethiopia: A community based cross-sectional study. Food science & nutrition, 2020. **8**(12): p. 6680-6690. https://doi.org/10.1002/fsn3.1962
74. Leroy, J.L. and E.A. Frongillo, Perspective: what does stunting really mean? A critical review of the evidence. Advances in Nutrition, 2019. **10**(2): p. 196-204. https://doi.org/10.1093/advances/nmy101
75. Perumal, N., D.G. Bassani, and D.E. Roth, Use and Misuse of Stunting as a Measure of Child Health. The Journal of Nutrition, 2018. **148**(3): p. 311-315. https://doi.org/10.1093/jn/nxx064
76. World Health Organization, Child growth standards and the identification of severe acute malnutrition in infants and children. A Joint Statement by the World Health Organization and the United Nations Children's Fund. Geneva: World Health Organization, 2009.

77. Ssentongo, P., et al., Global, regional and national epidemiology and prevalence of child stunting, wasting and underweight in low-and middle-income countries, 2006–2018. Scientific reports, 2021. **11**(1): p. 1-12. https://doi.org/10.1038/s41598-021-84302-w
78. Kibemo, B., et al., The association of socio-demographic and environmental factors with stunting among under-five children in Hawassa City, Sidama National Regional State, Ethiopia. Journal of Nutritional Science, 2022. **11**. https://doi.org/10.1017/jns.2022.29
79. Rodamo, K.M., et al., Magnitude and Associated Factors of Protein Energy Malnutrition among Children Aged 6-59 Months in Wondogenet District, Sidama Zone, Southern Ethiopia. Journal of Gynecology and Obstetrics, 2018. **6**(3): p. 47-55. http://dx.doi.org/10.11648/j.jgo.20180603.13
80. Alemayehu, M., M. Meskele, and B. Alemayehu, Prevalence and correlates of anemia among children aged 6-23 months in Wolaita Zone, Southern Ethiopia. PLoS One, 2019. **14**(3): p. e0206268. https://doi.org/10.1371/journal.pone.0206268
81. Woldie, H., Y. Kebede, and A. Tariku, Factors Associated with Anemia among Children Aged 6–23 Months Attending Growth Monitoring at Tsitsika Health Center, Wag-Himra Zone, Northeast Ethiopia. Journal of Nutrition and Metabolism, 2015. **2015**: p. 928632.
82. Orsango, A.Z., et al., Co-morbid anaemia and stunting among children 2–5 years old in southern Ethiopia: a community-based cross-sectional study. BMJ Paediatrics Open, 2021. **5**(1): p. e001039. https://doi.org/10.1136/bmjpo-2021-001039
83. Adish, A.A., et al., Risk factors for iron deficiency anaemia in preschool children in northern Ethiopia. Public Health Nutrition, 2007. **2**(3): p. 243-252. https://doi.org.10.1017/S1368980099000336
84. Fan, F.S., Iron deficiency anemia due to excessive green tea drinking. Clinical case reports, 2016. **4**(11): p. 1053. https://doi.org/10.1002/ccr3.707
85. Farah, A.M., B.S. Endris, and S.H. Gebreyesus, Maternal undernutrition as proxy indicators of their offspring's undernutrition: evidence from 2011 Ethiopia demographic and health survey. BMC nutrition, 2019. **5**(1): p. 1-12. https://doi.org/10.1186/s40795-019-0281-z
86. Chakrabarti, S., et al., Intergenerational nutrition benefits of India's national school feeding program. Nature Communications, 2021. **12**(1): p. 1-10. https://doi.org/10.1038/s41467-021-24433-w
87. Were, J.M., S. Stranges, and I.F. Creed, Fertility is a key predictor of the double burden of malnutrition among women of child-bearing age in sub-Saharan Africa. Journal of Global Health, 2020. **10**(2): p. 020423. https://doi.org/10.7189/jogh.10.020408
88. Young, M.F. and U. Ramakrishnan, Maternal Undernutrition before and during Pregnancy and Offspring Health and Development. Annals of Nutrition and Metabolism, 2020. **76**(3): p. 41-53. https://doi.org/10.1159/000510595
89. Weir, C.B. and A. Jan, BMI Classification Percentile And Cut Off Points. 2022. PMID: 31082114
90. Kumar, P., et al., Relationship between mid-upper arm circumference and BMI for identifying maternal wasting and severe wasting: a cross-sectional assessment. Public Health Nutr, 2019. **22**(14): p. 2548-2552. https://doi.org/10.1017/S1368980019000727
91. Christian, P., et al. Nutrition and maternal, neonatal, and child health. Seminars in perinatology, Elsevier, 2015. https://doi.org/10.1053/j.semperi.2015.06.009

92. Félix-Beltrán, L., J. Macinko, and R. Kuhn, Maternal height and double-burden of malnutrition households in Mexico: stunted children with overweight or obese mothers. Public Health Nutr, 2021. **24**(1): p. 106-116.
93. Damsgaard, C. T., et al., Trends in adult body-mass index in 200 countries from 1975 to 2014: A pooled analysis of 1698 population-based measurement studies with 19.2 million participants. The Lancet, 387(10026), 1377-1396. https://doi.org/10.1016/S0140-6736(16)30054-X
94. Turawa, E., et al., Prevalence of anaemia, iron deficiency, and iron deficiency anaemia in women of reproductive age and children under 5 years of age in south africa (1997-2021): A systematic review. International journal of environmental research and public health, 2021. **18**(23): p. 12799. https://doi.org/10.3390/ijerph182312799
95. Berihun, S., G.M. Kassa, and M. Teshome, Factors associated with underweight among lactating women in Womberma woreda, Northwest Ethiopia; A cross-sectional study. BMC Nutrition, 2017. **3**: p. 46. https://doi.org/10.1186/s40795-017-0165-z
96. Victora, C.G., et al., Effects of early-life poverty on health and human capital in children and adolescents: Analyses of national surveys and birth cohort studies in LMICs. The Lancet, 2022. https://doi.org/10.1016/S0140-6736(21)02716-1
97. Patel, A., et al., Maternal anemia and underweight as determinants of pregnancy outcomes: cohort study in eastern rural Maharashtra, India. BMJ Open, 2018. **8**(8): p. e021623. https://doi.org/10.1136/bmjopen-2018-021623
98. Elmadfa, I. and A.L. Meyer, Animal proteins as important contributors to a healthy human diet. Annual review of animal biosciences, 2017. **5**: p. 111-131. https://doi.org/10.1146/annurev-animal-022516-022943
99. Adesogan, A.T., et al., Animal source foods: Sustainability problem or malnutrition and sustainability solution? Perspective matters. Global Food Security, 2020. **25**: p. 100325. https://doi.org/10.1016/j.gfs.2019.100325
100. Iannotti, L.L., et al., Eggs early in complementary feeding increase choline pathway biomarkers and DHA: a randomized controlled trial in Ecuador. The American journal of Clinical Nutrition, 2017. **106**(6): p. 1482-1489. https://doi.org/10.3945/ajcn.117.160515
101. Herber, C. and L. Bogler, Association between milk consumption and child growth for children aged 6-59 months. Scientific Reports, 2020. **10**(1): p. 6730. https://doi.org/10.1038/s41598-020-63647-8
102. Lutter, C.K., L.L. Iannotti, and C.P. Stewart, The potential of a simple egg to improve maternal and child nutrition. Maternal & child nutrition, 2018. **14**: p. e12678. https://doi.org/10.1111/mcn.12678
103. McAfee, A.J., et al., Red meat consumption: An overview of the risks and benefits. Meat Science, 2010. **84**(1): p. 1-13. https://doi.org/10.1016/j.meatsci.2009.08.029
104. Balami, S., A. Sharma, and R. Karn, Significance of nutritional value of fish for human health. Malaysian Journal of Halal Research, 2019. **2**(2): p. 32-34. https://doi.org/10.2478/mjhr-2019-0012
105. Alagawany, M., et al., Nutritional strategies to produce organic and healthy poultry products. Sustainability of Agricultural Environment in Egypt: Part II, 2018: p. 339-356. https://doi.org/10.1007/698_2018_289

106. Bhandari, N. and R. Chowdhury, Infant and young child feeding. Proceedings of the Indian National Science Academy, 2016. **82**(5): p. 1507-1517. https://doi.org/10.16943/ptinsa/2016/48883
107. Ethiopian Public Health Institute (EPHI) and ICF, Ethiopia mini Demographic and Health Survey 2019: key indicators. Rockville, Maryland, USA: EPHI and ICF, 2019.
108. Abebe, Z., et al., Poor child complementary Feeding Practices in northwest Ethiopia: Finding from the Baseline Survey of Nutrition Project, 2016. Italian Journal of Paediatrics, 2019. **45**(1): p. 154. https://doi.org/10.1186/s13052-019-0747-2
109. Tessema, M., T. Belachew, and G. Ersino, Feeding patterns and stunting during early childhood in rural communities of Sidama, South Ethiopia. Pan African Medical Journal, 2013. **14**(1). https://doi.org/10.11604/pamj.2013.14.75.1630
110. Alemayehu, M., A. Argaw, and A.G. Mariam, Factors associated with malnutrition among lactating women in subsistence farming households from Dedo and Seqa-Chekorsa districts, Jimma zone, 2014. Developing Country Studies, 2015. **5**(21): p. 117-8.
111. Borrell, J.S., et al., Enset in Ethiopia: A poorly characterized but resilient starch staple. Annals of Botany, 2019. **123**(5): p. 747-766. https://doi.org/10.1093/aob/mcy214
112. Borrell, J.S., et al., Enset-based agricultural systems in Ethiopia: A systematic review of production trends, agronomy, processing and the wider food security applications of a neglected banana relative. Plants, People, Planet, 2020. **2**(3): p. 212-228. https://doi.org/10.1002/ppp3.10084
113. Yemata, G., Ensete ventricosum: A Multipurpose Crop against Hunger in Ethiopia. ScientificWorld Journal, 2020: p. 6431849. https://doi.org/10.1155/2020/6431849
114. Mohammed, B., M. Gabel, and L.M. Karlsson, Nutritive values of the drought tolerant food and fodder crop enset. African Journal of Agricultural Research, 2013. **8**(20): p. 2326-2333. https://doi.org/10.5897/AJAR12.1296
115. Nurfeta, A., et al., Yield and mineral content of ten enset (Ensete ventricosum) varieties. Tropical Animal Health and Production, 2008. **40**(4): p. 299-309. https://doi.prg/10.1007/s11250-007-9095-0
116. Selinus, R., A. Gobezie, and B. Vahlquist, Dietary studies in Ethiopia, Dietary pattern among the Sidamo ethnic group. A study on villagers in the enset monoculture area in Southern Ethiopia with special attention to the situation in young children. Acta Societatis Botanicorum Poloniae, 1971. **76**(3/4): p. 158-178.
117. Sonko, A., Assessment of dietary practice and anthropometric status of pregnant women in Aleta Chuko Woreda Southern Nations, Nationalities and People's Region/SNNPR/, Ethiopia. Journal of Epidemioly and Public Health Review, 2016. **1**(1): p. 1-9. http://dx.doi.org/10.16966/2471-8211.102
118. Quinlan, R.J., et al., Vulnerability and resilience of Sidama enset and maize farms in Southwestern Ethiopia. Journal of Ethnobiology, 2015. **35**(2): p. 314-336. https://doi.org/10.2993/etbi-35-02-314-336.1
119. Quinlan, R.J., et al., Culture and psychological responses to environmental shocks: Cultural ecology of Sidama impulsivity and niche construction in southwest Ethiopia. Current Anthropology, 2016. https://doi.org/10.1086/688213

120. Areru, H.A. and M.H. Dangisso, Births and deaths in Sidama in southern Ethiopia: Findings from the 2018 Dale-Wonsho Health and Demographic Surveillance System (HDSS), 2020. **13**(1): p. 1833511. https://doi.org/10.1080/16549716.2020.1833511
121. Branca, F., et al., The nutritional impact of seasonality in children and adults of rural Ethiopia. European Journal of Clinical Nutrition, 1993. **47**(12): p. 840-850.
122. Hirvonen, K., et al., Child growth faltering dynamics in food insecure districts in rural Ethiopia. Maternal & Child Nutrition, 2021. https://doi.org/10.1111/mcn.13262
123. Lomazzi, M., B. Borisch, and U. Laaser, The Millennium Development Goals: experiences, achievements and what's next. Global Health Action, 2014. **7**(1): p. 23695. https://doi.org/10.3402/gha.v7.23695
124. RudUcha, J., et al., How Ethiopia achieved millennium development goal 4 through multisectoral interventions: a countdown to 2015 case study. The Lancet Global Health, 2017. **5**(11): p. e1142-e1151.
125. Hamza, H.A., et al., Individual and community-level factors associated with animal source food consumption among children aged 6-23 months in Ethiopia: Multilevel mixed effects logistic regression model. PloS one, 2022. **17**(4): p. e0265899.
126. Bosha, T., et al., Dietary Diversity and Anthropometric Status of Mother–Child Pairs from Enset (False Banana) Staple Areas: A Panel Evidence from Southern Ethiopia. International Journal of Environmental Research and Public Health, 2019. **16**(12): p. 2170. https://doi.org/10.3390/ijerph16122170
127. Daba, A.K., et al., Determinants and constraints to household-level animal source food consumption in rural communities of Ethiopia. Journal of nutritional science, 2021. **10**. https://doi.org/10.1017/jns.2021.52
128. Keflie, T.S., et al., Dietary patterns and risk of micronutrient deficiencies: their implication for nutritional intervention in Ethiopia. Journal of Nutritional Health and Food Science, 2018. **6**(1): p. 1-16. http://dx.doi.org/10.15226/jnhfs.2018.001120
129. Unicef, Conceptual framework of the causes of malnutrition. New York: UNICEF, 1991.
130. Shi, L., et al., Variable selection and validation in multivariate modelling. Bioinformatics, 2019. **35**(6): p. 972-980. https://doi.org/10.1093/bioinformatics/bty710
131. Andersen, C.M. and R. Bro, Variable selection in regression—a tutorial. Journal of chemometrics, 2010. **24**(11-12): p. 728-737. https://doi.org/10.1002/cem.1360
132. Mellisse, B.T., et al., Home garden system dynamics in Southern Ethiopia. Agroforestry Systems, 2018. **92**(6): p. 1579-1595.
133. Mulu, E. and B. Mengistie, Household food insecurity and its association with nutritional status of under five children in Sekela District, Western Ethiopia: A comparative cross-sectional study. BMC Nutrition, 2017. **3**(1): p. 35. https://doi.org/10.1186/s40795-017-0149-z
134. Betebo, B., et al., Household Food Insecurity and Its Association with Nutritional Status of Children 6-59 Months of Age in East Badawacho District, South Ethiopia. Journal of Environmental and Public Health, 2017. **2017**: p. 6373595. https://doi.org/10.1155/2017/6373595
135. Abdurahman, A.A., et al., Household Food Insecurity May Predict Under weightand Wasting among Children Aged 24–59 Months. Ecology of food and nutrition, 2016. **55**(5): p. 456-472. https://doi.org/10.1080/03670244.2016.1207069

136. Getacher, L., G. Egata, and Y.A. Aynalem, Food insecurity and its predictors among lactating mothers in North Shoa Zone, Central Ethiopia: A community based cross-sectional study. BMJ Open, 2020. **10**(11): p. e040627. https://doi.org/10.1136/bmjopen-2020-040627
137. Orsango, A.Z., et al., Iron deficiency anemia among children aged 2–5 years in southern Ethiopia: a community-based cross-sectional study. PeerJ, 2021. **9**: p. e11649. https://doi.org/10.7717/peerj.11649
138. Haileselassie, M., et al., Why are animal source foods rarely consumed by 6-23 months old children in rural communities of Northern Ethiopia? A qualitative study. PloS one, 2020. **15**(1): p. e0225707.
139. Marques, R.d.F.d.S.V., et al., Anthropometric indices and exclusive breastfeeding in the first six months of life: A comparison with reference standards NCHS, 1977 and WHO, 2006. International Breastfeeding Journal, 2015. **10**(1): p. 1-7.
140. Tafesse, T., et al., Factors associated with stunting among children aged 6–59 months in Bensa District, Sidama Region, South Ethiopia: unmatched case-control study. BMC pediatrics, 2021. **21**(1): p. 1-11. https://doi.org/10.1186/s12887-021-03029-9
141. Wamani, H., et al., Boys are more stunted than girls in sub-Saharan Africa: a meta-analysis of 16 demographic and health surveys. BMC Paediatrics, 2007. **7**: p. 17. https://doi.org/10.1186/1471-2431-7-17
142. Medhin, G., et al., Prevalence and predictors of undernutrition among infants aged six and twelve months in Butajira, Ethiopia: the P-MaMiE Birth Cohort. BMC Public Health, 2010. **10**: p. 27. https://doi.org/10.1186/1471-2458-10-27
143. Belayneh, M., E. Loha, and B. Lindtjørn, 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. Ecology of Food and Nutrition, 2020: p. 1-26. https://doi.org/10.1080/03670244.2020.1789865
144. Gari, T., et al., Malaria increased the risk of stunting and wasting among young children in Ethiopia: Results of a cohort study. PLoS One, 2018. **13**(1): p. e0190983. https://doi.org/10.1371/journal.pone.0190983
145. Bork, K.A. and A. Diallo, Boys are more stunted than girls from early infancy to 3 years of age in rural Senegal. The Journal of nutrition, 2017. **147**(5): p. 940-947. https://doi.org/10.3945/jn.116.243246
146. Gosdin, L., et al., The co-occurrence of anaemia and stunting in young children. Maternal and Child Nutrition, 2018. **14**(3): p. e12597. https://doi.org/10.1111/mcn.12597
147. Berra, W.G., Household Food Insecurity Predicts Childhood Undernutrition: A Cross-Sectional Study in West Oromia (Ethiopia). Journal of Environmental and Public Health, 2020: p. 5871980. https://doi.org/10.1155/2020/5871980
148. Gibson, R.S., et al., Inadequate feeding practices and impaired growth among children from subsistence farming households in Sidama, Southern Ethiopia. Maternal and Child Nutrition, 2009. **5**(3): p. 260-75. https://doi.org/10.1111/j.1740-8709.2008.00179.x
149. Fentahun, N. and E. Alemu, Nearly One in Three Lactating Mothers Is Suffering from Inadequate Dietary Diversity in Amhara Region, Northwest Ethiopia. Journal of Nutrition and Metabolism, 2020: p. 7429034. https://doi.org/10.1155/2020/7429034
150. Biazin, B., et al., Smallholders' avocado production systems and tree productivity in the southern highlands of Ethiopia. Agroforestry systems, 2018. **92**(1): p. 127-137.

151. Adane, F., et al., The contribution of a fruit tree-based agroforestry system for household income to smallholder farmers in Dale District, Sidama Zone, Southern Ethiopia. Advances in Plants and Agriculture Research, 2019. **9**(1): p. 78-84. https://doi/org/10.15406/apar.2019.09.00415
152. Mulaw, G.F., K.U. Mare, and E.W. Anbesu, Nearly one-third of lactating mothers are suffering from undernutrition in pastoral community, Afar region, Ethiopia: Community-based cross-sectional study. PLoS One, 2021. **16**(7): p. e0254075. https://doi.org/10.1371/journal.pone.0254075
153. Dagnew, G.W. and M.B. Asresie, Factors associated with chronic energy malnutrition among reproductive-age women in Ethiopia: An analysis of the 2016 Ethiopia Demographic and Health Survey data. PLoS One, 2020. **15**(12): p. e0243148. https://doi.org/10.1371/journal.pone.0243148
154. Sserwanja, Q. and J. Kawuki, Prevalence of underweight and associated factors among lactating women in Ethiopia: a mini-review. Journal of Advances in Medicine and Medical Research, 2020: p. 1-9. https://doi.org/10.9734/JAMMR/2020/v32i830459
155. Boke, M.M., A. Yesuf, and B.T. Gutema, Prevalence of Undernutrition and Associated Factors among Lactating Mothers of Angecha District, Kembata Tembaro Zone, Southern Ethiopia. Journal of Nutrition and Metabolism, 202: p. 6691982. https://doi.org/10.1155/2021/6691982
156. Hailemariam, T.W., et al., Emerging Nutritional Problem of Adult Population: Overweight/Obesity and Associated Factors in Addis Ababa City Communities, Ethiopia—A Community-Based Cross-Sectional Study. Journal of Obesity, 2020. **2020**: p. 6928452. https://doi.org/10.1155/2020/6928452
157. Yeshaw, Y., et al., Determinants of overweight/obesity among reproductive age group women in Ethiopia: Multilevel analysis of Ethiopian demographic and health survey. BMJ Open, 2020. **10**(3): p. e034963. https://doi.org/10.1136/bmjopen-2019-034963
158. Abebaw, A., T.W. Gudayu, and B. Kelkay, Proportion of Immediate Postpartum Anaemia and Associated Factors among Postnatal Mothers in Northwest Ethiopia: A Cross-Sectional Study. Anemia, 2020: p. 8979740. https://doi.org/10.1155/2020/8979740
159. Bosha, A., et al., Nutritional and chemical properties of fermented food of wild and cultivated genotypes of enset (Ensete ventricosum). Food Research International, 2016. **89**(Pt 1): p. 806-811. https://doi.org/10.1016/j.foodres.2016.10.016
160. Julla, B.W., et al., Chronic energy deficiency and associated factors among lactating Mothers (15-49 years old) in Offa Woreda, Wolayita Zone, SNNPRs, Ethiopia. World Scientific Research, 2018. **5**(1): p. 13-23. https://doi.org/10.20448/journal.510.2018.51.13.23
161. Roba, K.T., et al., Concurrent iron and zinc deficiencies in lactating mothers and their children 6–23 months of age in two agro-ecological zones of rural Ethiopia. European Journal of Nutrition, 2018. **57**(2): p. 655-667. https://doi.org/10.1007/s00394-016-1351-5
162. Federal Democratic Republic of Ethiopia, Food and Nutrition policy of Ethiopia. Policy document, 2018.
163. Roba, K.T., et al., Seasonal variation in nutritional status and anemia among lactating mothers in two agro-ecological zones of rural Ethiopia: A longitudinal study. Nutrition, 2015. **31**(10): p. 1213-1218. https://doi.org/10.1016/j.nut.2015.03.007

164. Alemayehu, M., Factors associated with anemia among lactating mothers in subsistence farming households from selected districts of Jimma zone, south western Ethiopia: A community based cross-sectional study. Journal of Nutrition and Food Sciences, 2017. **7**(3).
165. Seifu, B. and D. Yilma, Prevalence and Associated Factors of Anemia among Lactating Women in Ethiopia from 2010 to 2020: A Systematic Review and Meta-Analysis. BioMed Res J, 2020. **5**(2): p. 327-342.
166. Ahankari, A.S., L.J. Tata, and A.W. Fogarty, Weight, height, and midupper arm circumference are associated with haemoglobin levels in adolescent girls living in rural India: A cross-sectional study. Maternal and Child Nutrition, 2020. **16**(2): p. e12908. https://doi.org/10.1111/mcn.12908
167. Temesgen, H., T. Yeneabat, and M. Teshome, Dietary diversity and associated factors among children aged 6–23 months in Sinan Woreda, Northwest Ethiopia: A cross-sectional study. BMC Nutrition, 2018. **4**(1): p. 1-8. https://doi.org/10.1186/s40795-018-0214-2
168. Broaddus-Shea, E.T., et al., Small-scale livestock production in Nepal is directly associated with children's increased intakes of eggs and dairy, but not meat. Nutrients, 2020. **12**(1): p. 252. https://doi.org/10.3390/nu12010252
169. Hetherington, J.B., et al., Livestock ownership, animal source foods and child nutritional outcomes in seven rural village clusters in Sub-Saharan Africa. Agriculture & Food Security, 2017. **6**(1): p. 1-11. https://doi.org/10.1186/s40066-016-0079-z
170. Kim, S.S. and P.H. Nguyen, Maternal behavioural determinants and livestock ownership are associated with animal source food consumption among young children during fasting in rural Ethiopia. Maternal and Child Nutrition, 2019. **15**(2): p. e12695. https://doi.org/10.1111/mcn.12695
171. Asresie, A., L. Zemedu, and E. Adigrat, The contribution of livestock sector in Ethiopian economy. A Review Advances in Life Science And Technology, 2015. **29**.
172. Hoddinott, J., D. Headey, and M. Dereje, Cows, Missing Milk Markets, and Nutrition in Rural Ethiopia. The Journal of Development Studies, 2015. **51**(8): p. 958-975. https://doi.org/10.1080/00220388.2015.1018903
173. Mosites, E., et al., Child height gain is associated with consumption of animal-source foods in livestock-owning households in Western Kenya. Public Health Nutr, 2017. **20**(2): p. 336-345. https://doi.org/10.1017/s136898001600210x
174. Melesse, M.B. and M. van den Berg, Consumer Nutrition Knowledge and Dietary Behavior in Urban Ethiopia: A Comprehensive Study. Ecology of Food and Nutrition, 2021. **60**(2): p. 244-256.
175. Aserese, A.D., et al., Adequate vitamin A rich food consumption and associated factors among lactating mothers visiting child immunization and post-natal clinic at health institutions in Gondar Town, Northwest Ethiopia. PloS One, 2020. **15**(9): p. e0239308.
176. Mulaw, G.F., F.W. Feleke, and K.U. Mare, Only one in four lactating mothers met the minimum dietary diversity score in the pastoral community, Afar region, Ethiopia: a community-based cross-sectional study. Jornal of Nutritional Science, 2021. **10**: p. e41. https://doi.org/10.1017/jns.2021.28
177. Workicho, A., et al., Household dietary diversity and Animal Source Food consumption in Ethiopia: evidence from the 2011 Welfare Monitoring Survey. BMC Public Health, 2016. **16**(1): p. 1192. https://doi.org/10.1186/s12889-016-3861-8

178. Melesse, K. and F. Beyene, Consumption pattern of milk and milk products in Ada'a woreda, East Shoa Zone, central Ethiopia. Livestock Research for Rural Development, 2009. **21**(4): p. 1-11.
179. Thumbi, S., et al., Linking human health and livestock health: a "one-health" platform for integrated analysis of human health, livestock health, and economic welfare in livestock dependent communities. PloS one, 2015. **10**(3): p. e0120761.
180. Azeze, T., et al., Utilization and quality of goat milk in Hadiya zone, Southern Ethiopia. Global Journal of Food Science and Technology, 2015. **3**(6): p. 197-203.
181. Omair, A., Selecting the appropriate study design for your research: Descriptive study designs. Journal of health specialties, 2015. **3**(3): p. 153.
182. Barraza, F., et al., General concepts in biostatistics and clinical epidemiology: Random error and systematic error. Medwave, 2019. **19**(7): p. e7687. https://doi.org/10.5867/medwave.2019.07.7687
183. Levine, M. and M.H. Ensom, Post hoc power analysis: an idea whose time has passed? Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy, 2001. **21**(4): p. 405-409.
184. Park, Y., et al., Comparison of self-reported dietary intakes from the Automated Self-Administered 24-h recall, 4-d food records, and food-frequency questionnaires against recovery biomarkers. American Journal of Clinical Nutrition, 2018. **107**(1): p. 80-93. https://doi.org/10.1093/ajcn/nqx002
185. Pourhoseingholi, M.A., A.R. Baghestani, and M. Vahedi, How to control confounding effects by statistical analysis. Gastroenterology and Hepatology from bed to bench, 2012. **5**(2): p. 79.
186. Rothman, K.J. and S. Greenland, Causation and causal inference in epidemiology. American Journal of Public Health, 2005. **95**(S1): p. S144-S150.
187. VanderWeele, T.J. and J.M. Robins, Four Types of Effect Modification: A Classification Based on Directed Acyclic Graphs. Epidemiology, 2007. **18**(5).
188. Wakeford, R., Association and causation in epidemiology - half a century since the publication of Bradford Hill's interpretational guidance. Journal of the Royal Society of Medicine, 2015. https://doi.org/10.1177/0141076814562713
189. Fedak, K.M., et al., Applying the Bradford Hill criteria in the 21st century: how data integration has changed causal inference in molecular epidemiology. Emerging themes in epidemiology, 2015. **12**(1): p. 1-9. https://doi.org/10.1186/s12982-015-0037-4
190. Szumilas, M., Explaining odds ratios. Journal of the Canadian Academy of Child and Adolescent Psychiatry, 2010. **19**(3): p. 227.
191. Blakstad, M.M., et al., Iron status is associated with worker productivity, independent of physical effort in Indian tea estate workers. Applied Physiology Nutrition Metabolism, 2020. **45**(12): p. 1360-1367.
192. Noble, H. and J. Smith, Issues of validity and reliability in qualitative research. Evidence-based nursing. Research Made Siple. 2015. **18**(2): p. 34-35. https://doi.org/10.1136/eb-2015-102054
193. Weise, A., et al., Assessing context suitability (generalizability, external validity, applicability or transferability) of findings in evidence syntheses in healthcare—An integrative review of methodological guidance. Research Synthesis Methods, 2020. **11**(6): p. 760-779. https://doi.org/10.1002/jrsm.1453

194. World Medical Associaiton Declaration of Helsinki, Ethical principles for medical research involving human subjects. Jama, 2013. **310**(20): p. 2191-4. https://doi.org/10.1001/jama.2013.281053

Appendices

Original papers I-III

Paper I

RESEARCH ARTICLE

Dietary practices and nutritional status of young children in the former ensete monoculture dominated Sidama region, southern Ethiopia: A community based cross-sectional study

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Abstract

Background

Child undernutrition is a challenge in Ethiopia, where morbidity and mortality among children are attributed to it. This study aimed to describe the dietary practices, household food insecurity, and nutritional status of young children in Dale district, Sidama region, southern Ethiopia. We discuss our findings in light of research from the same area 3 to 5 decades ago, and we analyze factors associated with linear growth of young children.

Method

A community-based cross-sectional study design was employed. Children less than two years old and their primary caretakers (n = 903) were included in this study. Among whom 791 children were aged above six months and 742 children out of 791 provided a 24-hour dietary recall. Interviews capturing other dietary practices, food insecurity, socio-demographic characteristics, anthropometric measurements, and haemoglobin assessments were performed for all. The WHO Child Growth Standards were used to calculate anthropometric indices and to describe stunting (length-for-age z-score <-2). Haemoglobin measures below 11g/dl were defined as low haemoglobin levels (anaemia). Multilevel linear regression was used to identify factors associated with length-for-age z-scores.

Result

The prevalence of stunting, wasting, and anaemia was 39.5%, 3.9%, and 61.7%, respectively. The majority of children (97%) ate cereals (maize) during the past 24 hours, and 79.6% of households use maize as the main food. Three fourth (75%) of the total households were food insecure ranging from mild to severe food insecurity. Boys were at higher

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risk of having lower length-for-age z-score than girls (β -0.53; 95% Confidence Interval (CI): -0.78, -0.27). For each month the children grew older, length-for-age z-score decreased slightly (β -0.06; -0.07, -0.04). Household food insecurity scores (β -0.05; -0.08, -0.01) and children haemoglobin levels, (β 0.21; 0.06, 0.35) were also associated with length-for-age z-score among young children.

Conclusion

Linear growth failure (stunting) was prevalent among young children in the rural Sidama region and the majority of them were also anaemic. Older age, male sex, a lower haemoglobin level in children, and household food insecurity were risk factors of linear growth failure in young children. Maize seems to be the dominant food in this previously ensete dominated area; however, there have been minimal improvements in length-for-age z-score over decades. Strategies to ensure household's food access and improve the quality of child diets need to be implemented.

Introduction

Child undernutrition can be described both in relation to diet and nutritional status. Stunting, being too short for one's age, is defined as a height/length-for-age Z-scores below minus two standard deviations (< -2 SD) from the Standard population mean [1] and height/lenth-for-age is an expression of attained linear growth performance. The global prevalence of child stunting in 2018 was 22% affecting over 149 million children under the age of five years [2].

In Ethiopia, the national prevalence of stunting among children under the age of five years was reported at 37% in 2019; which was 38% in 2016 [3, 4]. The national level prevalence of wasting was reported at 7% in 2019. In a similar national report, it was indicated that the prevalence of stunting and wasting in southern Ethiopia were 36.4% and 6.3, respectively in 2019, thus similar to the national average. A study done in Simada zone (currently Sidama region) in 2008 reported that 52% of children aged 12–23 months were stunted. Anaemia is also a major problem among children under the age of five years in Ethiopia, affecting 50% in 2016 [4]. A recent study from Wolayta zone, southern Ethiopia, also reported a high prevalence of anamia (65%) among children aged 6 to 23 months [5]. On top of this, only 11% of children aged 6–23 months in Ethiopia were getting a minimum acceptable diet in 2019 [3]. Sub-optimal child feeding practices are common in different parts of the country ranging from 42% in Addis Ababa to 98% in Somali [3]. The prevlaence of minimum dietary diversity was also reported at 35% in morth-west Ethiopia [6].

About 20 million people live in the southern and southwestern parts of Ethiopia where ensete (*Ensete ventricosum)* has been the major staple food [7]. The pseudostem and the corm of this "false banana" are used for food. However, the food contents show that the plant is rich in carbohydrates (80%), fibers (7%), and deficient in proteins (4%), fats (0.4%), vitamins, and other micronutrients [8, 9]. Most of the residents in rural Sidama are farmers who have been cultivating ensete as the main staple food for decades [8, 10, 11].

Ensete, also known as "the tree against hunger" has multiple benefits in addition to being a staple food and fodder for livestock, it is considered as being environment friendly [12, 13]. The people living in the ensete monoculture area were less affected by the drought and famine occurring in Ethiopia during the years from 1972 to 1985. Most recently other crops, particularly maize, tend to dominate due to the short harvesting time compared to ensete [14]. Cash crops such as fruits, coffee, and chat are covering large farms as income-generating resources, and ensete has gotten less attention. Moreover, a recent rapid population growth [15, 16] leading to increased population density has led to declining availability of farming areas. Therefore, the replacement of ensete with maize and other cash crops, and the rapid population growth, ultimately risk food insecurity. However, the impact of these changes on household food security and the nutritional status of children has not been adequately understood.

Children living in this ensete monoculture area have been affected by linear growth failure (stunting) for decades. Linear growth failure occurring during the first 1000 days of life is critical because of its negative consequences such as poor health, reduced learning capacity, and low economic productivity later in life [17–19]. However, few studies have reported on linear growth failure and its correlates among children less than two years old.

Our study aimed to describe nutritional status and dietary practices of young children less than two years, a critical period in which undernutrition develops, and to describe household food insecurity. In addition, we modelled how various factors affected linear growth. We are discussing our findings in light of high-quality nutritional studies done three to five decades ago. To our knowledge, limited nutritional studies have been done in this area in between those studies, and ours. Further, our study aimed to analyze the risk factors of linear growth faltering in the rural ensete monoculture dominated Dale district, Sidama region, southern Ethiopia.

Materials and methods

Study design and setting

A community-based cross-sectional study was conducted from August to November 2018 in seven randomly selected rural kebeles of Dale district. A kebele is the lowest administrative unit in the Ethiopian context. Dale district has a total of 36 rural and 2 urban kebeles. The main town in the district, Yirga Alem is located 320 km from Addis Ababa. The total population of Dale district was estimated at about 270,000 in 2017 and it is among the most densely populated districts (around 876 people/km^2) in the country. The Dale district has 33 health posts, 10 health centres, and one referral hospital, Yirga Alem hospital. Most rural kebeles in the district have at least one health post operated by health extension workers. Services provided in the health posts are limited to immunization and family planning; no nutrition-based service was provided. Even though there is a non-governmental program, the productive safety net program (PSNP) working on severe household food insecurity, it is limited to a very few kebeles in the region [20].

Ensete (*Ensete ventricosum*) is widely cultivated in the area, and other food crops include maize, kale, cabbage, potato, and haricot beans. Coffee, chat (*Catha edulis*), and fruits like avocado and banana are the main cash crops grown in the area. The community also keeps livestock, and the livestock feed on ensete, and the animal manure is used as a natural fertilizer for the ensete cultivation.

Study participants and sample size estimation

We visited homes with children younger than two years with mothers as the primary respondents or in her absence another primary caretaker. A baseline survey was conducted to list all eligible households in each of the study kebeles. Using a proportional allocation, households from each kebele were selected by a simple random method in statistical package for social science (SPSS) version 20 (IBM Corp, 2011). In households with more than one eligible child, one child was selected by a lottery method. If any of the children died or left the area before enrolment, the next household with a child under the age of two years was taken. A total of 91 replacements were made; two for the deaths of the selected children and the rest had permanently left the area.

The sample size was calculated using Open Epi version 3.01 (Dean AG, Sullivan Km, 2013) statistical software by assuming the proportion of the outcome variable; stunting, 95% confidence level, 4% precision, and 1.5 design effect. Although the Ethiopian demographic and health survey (2016) reported that the prevalence of stunting in southern Ethiopia was 39% [4], it was for children under the age of five years. Thus due to the intention to maximize our sample size, a proportion of 50% was assumed for this study. By adding a 10% non-response rate, the final sample size was set to 990 households with children under two years.

Study variables

Dietary practices and nutritional status including length-for-age z-score (LAZ) and weight-for-length (WLZ) were described. Factors associated with LAZ were assessed including the child's age, sex, birth order, and haemoglobin levels. Maternal characteristics included age, height stature, haemoglobin level, and educational status. Mother's height was captured based on reported intergenerational effect [21] and previous studies in Ethiopia having identified it as important [22, 23]. Household factors included household's food insecurity, wealth index, and family size.

Data collection procedures

Data was collected through face-to-face interviews conducted in the local language, *Sidaamu Afoo*. A structured and pretested questionnaire was used to collect household socio-demographic and socio-economic characteristics, child background, feeding habits, and illness experiences. All the questionnaires used were prepared in English and translated to Amharic (the official language) and then to *Sidaamu Afoo* (the local language). Back translation was also done to check for consistency. Anthropometric measurements were done in the household's compound and in places suitable to fix the measuring instruments; weight scales and length boards. Six data collectors (four nurses and two laboratory technicians) and two immediate supervisors were trained and participated in the data collection. The overall data collection activities were closely monitored by the investigators. Information on birth date and birth weight was obtained from the child immunization card. In the absence of an immunization cards, all the information was obtained from the respondent. In situations where the consented mother was not available for the interview for personal or practical reasons, mostly her consenting husband spoke on her behalf and provided some information related to her age and level of education. Measurements of her height, weight, and haemoglobin were taken during the interview visits or on other scheduled visits.

Data quality control

Efforts such as confirmation of data with records like immunization cards and designing some questions in different ways for cross-checking were used. Calibration and regular cleaning of measuring instruments were done. Measurements (weight and length) were taken twice. Intensive training and close supervision of data collectors and using the local language for interviews were also additional strategies we pursued.

Nutritional status of children

Digital SECA scales (SECA GmbH, Germany) were used to measure the weights of the child with minimal clothing. UNICEF length measuring boards with a fixed headboard, a movable footboard, and a ruler was used to take the recumbent length of the child to the nearest 0.1 cm. Length and weight were taken twice and recorded in a separate column as measurement one and measurement two. The average weight and length of children were calculated during data entry.

Anthropometric data and age in months were exported to Emergency Nutrition Assessment for Standardized Monitoring Assessment of Relief and Transitions software (Erhardt, Golden, and Seaman, 2011). Anthropometric indices were computed based on the World Health Organization, 2006 Child Growth Standards. The output was again exported to the statistical package for social sciences (SPSS) version 25 (IBM Corp, 2017) for further analysis. The prevalence of stunting and wasting were defined using WHO Child Growth Standards cut-off points [1], LAZ $<$ -2, and WLZ $<$ -2, respectively.

Haemoglobin levels of children and their biological mothers were measured with HemoCue HB 301 (Angelholm, Sweden) machines using finger-prick capillary blood samples. Haemoglobin levels were adjusted for altitude at 1500 metres and cut-off points were taken as 11g/dl for children [24] and 12.5g/dl for mothers [25] to determine the prevalence of anaemia. Illness experience was defined as the occurrence of any illness of the study child within two weeks preceding the survey.

Dietary practices

Dietary diversity score was computed for children aged 6 to 24 months as that was the age range supposed to have started complementary feeding [26]. Data on the consumption of 10 food items by the child was obtained using a 24-hour dietary recall. The use of fats, sweets, and commercial/fortified foods by the child was also asked. The dietary diversity score was calculated from the 9 food items: cereals, roots and tubers, dairy products, legumes, flesh foods (including organ meats), eggs, fruits, green leafy vegetables, and other vegetables. The mean dietary diversity score and prevalence of minimum dietary diversity were computed based on the nine food groups. Minimum dietary diversity (MDD) was defined as the proportion of children aged between 6 and 24 months who received food from four or more food groups in the 24 hours prior to the study.

Household food insecurity

Household Food Insecurity Access Scale (HFIAS) developed by the Food and Nutrition Technical Assistance (FANTA, 2007) and validated for use in Ethiopia [27] was employed to measure household food insecurity. The tool comprises nine questions 1) Uncertainty about food supply, 2) Unable to eat preferred food, 3) Eat a limited variety of food, 4. Eat foods really do not want to eat, 5) Eat smaller meals, 6) Eat fewer meals, 7) No food of any kind in the household, 8) Go to sleep at night hungry, and 9) Go a whole day and night without food. The tool measures the three food insecurity domains: uncertainty about food supply, poor dietary quality, and insufficient food intake and its physical consequences [27, 28]. Respondents were asked if they had faced any of those nine situations in the four weeks preceding this study. All 'yes' responses were followed by frequency questions coded with numbers; 1; if it happened once or twice, 2; if it happened three to ten times, and 3; if it happened more than ten times. All 'No' responses were scored '0' for the frequency of occurrence. Households were classified into food secure, mildly food insecure, moderately food insecure, and severely food insecure based on Food and Nutrition Technical Assistance classification guidelines [29]. The HFIAS score ranged from 0 to 27, where a lower value was less and a higher value was more food insecurity. Categorical and continuous descriptive summaries are presented with tables and texts.

Operational definition of household food insecurity categories

A food-secure household did not experience any food insecurity situation or only rarely experienced worry about food supply.

A mild food-insecure household is a household that experienced uncertainty about having enough food sometimes or often; and/or inability to eat the preferred food item rarely, sometimes or often; and/or eat a limited variety of food and eat a food that really do not want to eat rarely.

A moderate food-insecure household is a household that experienced eating a limited variety of food sometimes or often; and/or eating food that really did not want to eat sometimes or often; and/or eating smaller meals or fewer meals in a day rarely or sometimes.

A severe food-insecure household is a household that experienced eating smaller size of meals or fewer meals in a day often; and/or experienced any of the three most severe conditions of food insecurity; no food of any kind in the household, or going to bed hungry at night, or going a whole day and night without eating even if it occurred rarely.

Wealth index

Wealth index was defined as a household's economic status. Wealth index was computed by a principal component analysis (PCA) using possession of household assets such as radio, television, mobile phone, and livestock such as cow, sheep, goat, donkey, and hens [30, 31]. The Kaiser Meyer Olkin (KMO) sampling adequacy test was 0.62 with a significant level (<0.001) Bartlett's Test of Sphericity. Four out of nine components had an eigenvalue greater than 1. Finally, households were ranked based on percentile scores and grouped into three economic statuses: very poor, poor, and least poor.

Data cleaning

Data cleaning started at the time of data collection. All questionnaires were checked for completeness and any missing information was recaptured. The data was double entered and validated using Epi Data 3.1 (Epi Data Association, Odense, Denmark) software. SPSS version 25 (IBM Corp, 2017) was used to check for any missing values, outliers, and inconsistent information. A total of 82 cases were excluded from the analysis due to multiple missing values which were difficult to recapture, the uncertainty of child's age, and other reasons as shown with Fig 1. Visit dates and birth dates were converted to the Gregorian calendar from the Ethiopian calendar using date conversion application software.

Statistical analysis

Data analysis was done using SPSS version 25 (IBM Corp, 2017), and STATA version 12 for windows (Stata Corp LP, College Station, TX, 2011). Descriptive statistics; means, medians, frequencies, and percentages are used to present the continuous and categorical variables. Bivariate linear regression was carried out for 20 independent variables to identify variables with a p-value less than 0.25 at a 95% CI for multivariable linear regression. Multicollinearity was also checked for the selected independent variables using collinearity diagnostics. Crude and adjusted linear regression models were applied to describe associations with anthropometric indices, length-for-age z-score (LAZ). Statistical significance was set at p-value ≤ 0.05 and the regression coefficients with the 95% confidence interval (CI) were reported. To account for clustering at kebele level, (ICC = 0.051), adjustment with the vce option in STATA was used for our final model. The model performance was assessed with the model goodness of fit which was not significant.

Ethical considerations

Ethical clearance was obtained from Hawassa University, Ethiopia (Ref. No IRB/025/10, Date: 21/12/2017) and the Ethical committee of Western Norway, Norway (Ref: 2017/90/REK, Date: 07/03/18). All the necessary official letters were obtained from the concerned bodies. Written informed consent was obtained from respondents and legal guardians of children, usually the mother or the father. In the case of illiterate respondents, the data collector had to read the subject information and obtained a finger stamp when they agreed to participate. The data is kept in a secure place to maintain confidentiality. Furthermore, identifiers like household identification numbers were not used to communicate findings. This study was carried our following all applicable standards principles of the World Medical Association Declaration of Helsinki, 2013 [32].

Result

Background information

Out of the 985 children whose guardians consented to data collection, 903 (91.7%) were analysed in this paper (Fig 1). Of the 903 respondents, 876 (97%) were mothers, and the rest 27 (3%) were non-maternal caregivers, of whom 2 mothers had died and no maternal data was obtained. Non-maternal caregivers, mostly fathers, provided information about the mother (n = 21) or stepmother (n = 4). We had measurement data from the 876 responding and the 21 non-responding biological mothers, in total 897. The mean (SD) household size was 4.8 (1.6) and 459 (50.8%) of the 903 households had 2 to 4 members (Table 1). In 808 (89.5%) of the total households, there was only one child who was under the age of five years (including the index child). Maize was the main food for 719 (79.6%) of the total households and only 175 (19.4%) of them reported using ensete as the main food. Majority, 713 (79%) of the total

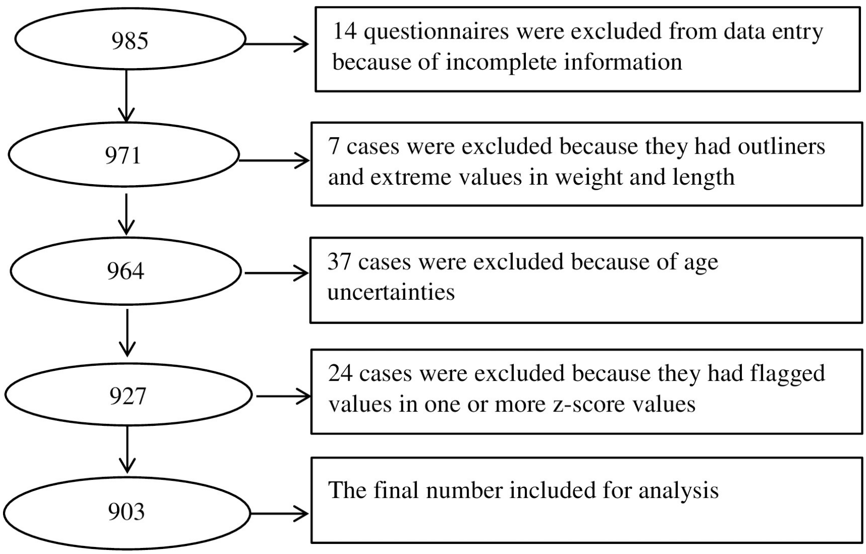

Fig 1. Flow chart showing a stepwise exclusion of the study subjects during data cleaning and analysis.

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Table 1. Household factors and characteristics of mothers of the study children in Dale district, Ethiopia, 2018 (n = 903, except where otherwise indicated).

Variable	Category	Frequency (N)	Percent (%)
Respondent	Mother	876	97.0
	Father	16	1.8
	Others	11	1.2
Family size	2–4	459	50.8
	5–7	387	42.9
	>7	57	6.3
Children < 5 years of age in the HH	One	808	89.5
	More than one	95	10.5
Wealth status	Very poor	279	30.9
	Poor	325	36.0
	Least poor	299	33.1
Common food used for the family	Maize	719	79.6
	Ensete	175	19.4
	Teff and other	9	1.0
Main source of food for the HH	Household farm	713	80.0
	Local marketing	187	20.7
	Other sources	3	0.3
Main source of water for the HH	Tap-water	350	38.8
	Protected well/spring	362	40.1
	Unprotected well/spring	164	18.2
	Other sources	27	3.0
Age of the mother (n = 897)	15–24 years	282	31.4
	25–34 years	518	57.7
	35–49 years	97	10.8
Mother's educational status (n = 897)	No education	160	17.8
	Primary school	407	45.3
	Secondary school	330	36.8
Total number of pregnancies (n = 897)	One	260	29.0
	Two to three	376	41.9
	Four and above	261	29.1
Age at first pregnancy (n = 897)	< 20 years	791	88.2
	20 to 35 years	91	10.1
	Do not remember	15	1.7
Hemoglobin level of the mother (897)	< 12.5 g/dl	158	17.6
	≥ 12 g/dl	**739**	**82.4**

CI = confidence interval.
HH = household.

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households, used their production as the main source of food. For 362(40.1%) of the total households, a protected well or spring was the main source of water (Table 1). Near to three-fourth, 661 (73.2%) of the total households were keeping cows and more than half, 529 (58.6%) of the 903 households owned hens.

Maternal characteristics

The age range of mothers (n = 897) was 16–45 years and the mean (SD) age was 26.9 (5.1) years. More than 40% (407 of the 897) had attended primary school education and 5 (0.5%) of the 897 mothers were employed. The mean (SD) age of mothers at first pregnancy was 17.9 (1.8) years while 15 mothers did not remember their age at first pregnancy. About 30% (264) of the 897 mothers had only one pregnancy. Haemoglobin levels were recorded less than 12.5g/dl for 158 (17.6%) of the 897 mothers (Table 1).

Child characteristics

Of the 903 children (447 male and 456 female) who participated in our study, 537 (59.5%) were aged 12–24 months (Table 2). The mean (SD) age was 14.1 (6.3) months (S1 Table). The immunization card was accessed for 547(60.6%) of 903 children. More than half of the total children were born at health centres 430 (47.6%) or hospitals 120 (13.3%). Of the 903 children, 265 (29.3%) were recorded as the first child to their mother. Information on birth weight was obtained for 722 (80%) of the total children and 249 (34.5%) of them were confirmed from the immunization cards. Illness during two weeks prior to this study was reported by 72 (8%) of 903 children; majority of them (40 of 72) experienced cough or cough and fever (Table 2).

Nutritional status of children aged 0 to 24 months

The prevalence of stunting (LAZ < -2) was 39.5% (357out of 903 children) and out of them 163 (45.7%) were severely stunted (LAZ < -3). The mean (SD) length-for-age z-score was -1.6

Table 2. Child characteristics and young child feeding practices in Dale district, Ethiopia, 2018, categorical variables (n = 903, except where otherwise indicated).

Variable	Category	Frequency (N)	Percent (%)
Age in months	< 6 month	112	12.4
	6–12 month	254	28.1
	12–24 months	537	59.5
Sex of the child	Male	447	49.5
	Female	456	50.5
Birth order	First child	265	29.3
	Second and above	638	70.7
Place of birth	Home	344	38.1
	Health center	430	47.6
	Hospital	120	13.3
	Other	9	1.0
Birth weight (N = 722)	< 2.5 kg	93	12.9
	≥ 2.5 kg	629	87.1
Breastfeeding initiation	Within the 1st hour after birth	698	77.4
	After the 1st one hour after birth	204	22.6
Exclusive Breastfeeding (Children < 6 months, n = 112)	Yes	88	78.6
	No	24	21.4
Complementary Feeding (6–24 months age, n = 791)	Yes	742	93.8
	No	49	6.2
Illness in the past two weeks	Yes	72	8.0
	No	831	92.0
Type of illness (N = 72)	Cough	31	43.1
	Diarrhea	7	9.7
	Fever	8	11.1
	Cough and fever	9	12.5
	Diarrhea and fever	15	20.8
	Other	2	2.8

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(1.7). The prevalence of wasting was 3.9% (35 out of 903) and out of them, 12 (34.3%) were severely wasted (WLZ < -3). The adjusted haemoglobin level of 557 (61.7%) of the 903 children was below 11g/dl (Table 2). The descriptive output for haemoglobin level, weight, length, anthropometric indices, and other continuous variables are presented in S1 Table.

Dietary practices

Almost all, 896 (99.2%) of the total children were being breastfed at the time of data collection. Among the 7 children not being breastfed, all were above 6 months; two had lost their mothers, and 5 had different reasons like separation from the mother and occurrence of new pregnancy. More than three-fourth (698 of 903) the mother-child dyads had started breastfeeding with in the first one hour after delivery.

Although all children below the age of six months (112) were breastfed, exclusive breastfeeding was practiced by 88(78.6%) of 112 children aged below six months (Table 2). The rest 24/(21.4%) of them had started taking food. Out of 791 children aged 6 to 24 months, 49 (6.2%) children had not started complementary feeding. Out of them, 25 were aged 6 to 7 months, 20 were aged 7 to 8 months, and 3 were aged 8 to 9 months, and one child was above 9 month. Out of the 742 children aged above six months who had started complementary feeding, 16 (2.0%) reported that they had started complementary feeding before the age of six months (Table 2).

Dietary diversity score was computed for children above six months who had started complementary feeding, 742 (82.2%) of 903 children. The mean (SD) dietary diversity score was 4.3 (1.9) and the minimum score was 1 out of 9 and the maximum score was 9 out of 9. Minimum dietary diversity, defined as consumption of foods from five or more food groups, was practiced by 452 (39.1%) of 742 children. The common food group consumed were cereals 720 (97%) followed by dairy products, 557 (75.1%) of the 742 children. More information can be seen in Table 3.

Household food insecurity status

The mean (SD) household food insecurity score was 4.0 (3.2). Three-fourth (677) of the total households were food insecure and prevalence of severe food insecurity was 17.8% (161 of 903

Table 3. Consumption of food groups during the past 24 hours in rural Dale district, Ethiopia, 2018 (n = 742).

	Consumption in the past 24 hours			
	Yes		No	
List of food groups	**Frequency (N)**	**Percent (%)**	**Frequency (N)**	**Percent (%)**
Cereals, including maize	720	97.0	22	3.0
Roots and tubers including ensete	547	73.7	195	26.3
Legumes and nuts	96	12.9	646	87.1
Dairy products	557	75.1	185	24.9
Flesh foods	24	7.3	688	92.7
Eggs	272	36.7	470	63.3
Green leafy vegetables	298	40.2	444	59.8
Other vegetables	141	19.0	601	81.0
Fruits of all types	476	64.2	266	35.8
Fats and oils	411	55.4	331	44.6
Sugar and sweets	147	19.8	595	80.2
Commercial/fortified foods	75	10.1	667	89.9

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Table 4. Households' experience and frequency of occurrence of food insecurity conditions in Dale district, Ethiopia, 2018, during the past four weeks (n = 903).

Household food insecurity conditions	Frequency of occurrence over the past four weeks			
	Never	Rarely	Sometimes	Often
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)
Worried about getting enough food	386 (42.7)	348 (38.5)	157 (17.4)	12 (1.3)
Unable to eat preferred foods	390 (43.2)	317 (35.1)	190 (21.0)	6 (0.7)
Ate a limited variety of foods	347 (38.4)	310 (34.3)	181 (20.0)	65(7.2)
Ate foods that really did not want to eat	715(79.2)	142 (15.7)	42 (4.7)	4 (0.4)
Ate a smaller meal	571 (63.2)	206 (22.8)	122 (13.5)	4 (0.4)
Ate fewer meals in a day	640 (70.9)	186 (20.6)	74 (8.2)	3 (0.3)
No food of any kind in the household	814 (90.1)	59 (6.5)	29 (3.2)	1 (0.1)
Went to sleep at night hungry	805 (89.1)	79 (8.7)	19 (2.1)	0
Went a whole day and night without eating	860 (95.2)	35 (3.9)	7 (0.8)	1 (0.1)

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households). The highest affirmative answer, 556 (61.6) of 903 was given for 'Eating a limited variety of foods' followed by 'worry about having enough, 517 (61.1%) of 903. The occurrence frequencies for the nine household food insecurity conditions are presented in Table 4.

Association of independent variables with length-for-age Z score

The result of the bivariable and multivariable linear regression models are presented in Table 5. The age, sex, haemoglobin level of the child and household food insecurity score were independently associated with length-for-age z-score (LAZ). LAZ decreased by 0.06 (β-0.06; -0.07, -0.04) when the age increased by one month. Male sex of the child was associated with a decrease of LAZ by 0.53 (β-0.53; -0.78, -0.27) compared to being female. An increase in the haemoglobin level of the child by 1g/dl was associated with an increase in LAZ by 0.21 (β 0.2; 0.06, 0.35). When the household food insecurity score increased by one (more food insecure), LAZ decrease by 0.05 (β-0.05; -0.09, -0.01).

Table 5. Effect of selected predictor variables on length-for-age z-scores among 903 children 0 to 24 months of age in Dale district, southern Ethiopia, 2018.

Variables	Unadjusted coefficients	95% CI for the unadjusted coefficients	Adjusted coefficients	95% CI for the adjusted coefficients
Age in months	**-0.05**	**-0.07, -0.04**	**-0.06**	**-0.07, -0.04**
Male sex	**-0.56**	**-0.91, -0.21**	**-0.53**	**-0.78, -0.27**
Birth order	**0 .12**	**0.05, 0.20**	0.07	-0.1, 0.3
Child hemoglobin	**0.18**	**0.02, 0.34**	**0.21**	**0.06, 0.35**
Mother's age	0 .02	-0.01, 0.04	-0.01	-0.05, 0.03
Mother's height	0.02	-0.01, 0.04	0.03	-0.01, 0.06
Education of mother				
Primary school education[1]	-0.39	-0.84, 0.05	-0.33	-0.87, 0.23
Secondary school education[1]	**-0.41**	**-0.79, -0.03**	-0.26	-0.75, 0.22
HFI score	-0.05	-0.12, 0.02	**-0.05**	**-0.09, -0.01**
Family size	0.11	0.02, 0.2	0.04	-0.1, 0.18
Wealth status				
Poor[2]	0.05	-0.44, 0.53	0.09	-0.31, 0.49
Least poor[2]	-0.26	-0.97, 0.44	-0.24	-0.86, 0.39

[1]Compared with no education (the reference category).

[2]Compared with very poor (the reference category).

CI = confidence interval.

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Discussion

Our finding showed that linear growth failure among rural young children was high 39.5%. About 60% of young children were not getting the minimum dietary diversity and 75% of the households were food insecure. The majority were initiating breastfeeding within one hour and exclusive breastfeeding was practiced to a high degree. Although complementary feeding had started at the right time for most babies, it was also delayed for 6% of them. Thus, food insecurity, incomplete diet and lack of complementary feeding were nutritional threats among the young children in this study. The majority of the households used maize as a staple food. Older child age, being male, lower haemoglobin levels of the child, and household food insecurity were associated with lower LAZ scores.

We discuss our findings in light of studies done 3 and 5 decades ago and focus on the areas of infant and toddler dietary practices and child anthropometry. Risk factors for linear growth failure are discussed in light of current literature. One of the oldest studies was conducted in 1971 [10] and of relevance to us is their presentation of the child diet. The other study was done in 1993 [33] and it presents child anthropometry.

Child nutritional status

The study from the 90-ties evaluated the nutritional impact of seasonality in children [33]. The study documented that the mean height-for-age z-score was -2.2, which is lower than the mean (SD) in our study, -1.6 (1.7). Although we used WHO (2006) Growth Standards as a reference, F. Branca and colleagues used WHO reference values from 1983 (NCHS reference population), there are reasons to believe that for longitudinal growth impairment, the new standard corresponds to slightly higher values than in the old reference. Therefore, the mean difference would be the difference between -2.2 and -1.6 or more, not less. One can expect an improvement of one-half of a standard deviation in longitudinal growth over 30 years which is seemingly a small improvement over such a long period with a high level of undernutrition. The prevalence of stunting (39.5%) is still alarming.

Dietary practices

Our study demonstrated a change in the staple food of the rural community of Sidama region compared to studies carried out decades ago. In our study, maize was the commonly used staple food for about 80% of the households, and ensete was found less prominent in the diet; nearly 20%. In the 1970-ties [10] it was reported that ensete was the main staple food of the family including young children. However, in our study ensete was the second common food used for young children next to maize. Thus, there is a reason to believe there has been a dietary shift from ensete to maize among the rural residents of the region. This dietary shift might be due to the adaptation of the newly introduced crop, maize, which is considered as the modern approach [14]. Moreover, the cultivation of crops like maize, coffee, chat, and fruits might be an income-generating activity. Crop diversification is encouraged to improve dietary diversity [34] and sustainability. On the other hand, draught and poverty, may lead to unsustainable choices or risk taking and ultimately increased vulnerability. As a result there may be a progressive decline in ensete production [14]. In the 70-ties it is described that kale was always served with ensete. However, in our study, green leafy vegetables were served to 40% of children during the past 24 hours. These may indicate that vegetable consumption has gone down and that toddlers are eating less nutritious vegetables than recommended.

The previous study [10] reported that it was a culture feeding fresh butter, boiled water, and fenugreek home preparations from the day of birth. Such cultural practices play an important role in disturbing the normal digestion among young children, hence causing undernutrition and ill health. However, in our study, pre-lacteal foods were given to 4.3% of the children, and exclusive breastfeeding was practiced among 78% of children under the age of six months. This may indicate emphasized messages that changed practices in favour of breastfeeding. In our study, bottle-feeding was used for 2.2% of the children, which was not practiced in the previous studies. Bottle-feeding should not be a primary choice in situations where mothers can spend adequate time with their babies. Even though the use of bottle-feeding seems to be low (2.2%), it is considerable for a rural community where less than 1% of mothers were employed.

Milk was consumed by 75% of the children in our study during the past 24 hours. It was served diluted with water or after traditional extraction of the fat (butter). This may be due to prior public health messages on what to do when breastfeeding cannot be achieved and formula milk is unaffordable [35, 36]. The current use of diluted cow's milk where breastfeeding is almost universal needs further explanation and understanding. Reasons for using diluted milk may include separation from the mother and the need for alternative feeds. The need for earning money from selling the milk or fat (butter) extracted might give an additional explanation [37]. Since milk is the only animal source food given to children in the study area, critical consideration of its quality is needed. It may be possible to conclude that children nowadays get a diet less calorie-dense than earlier as fats and oils only were served to half of the children above 6 months.

In the 70-ties [10] animal-source protein intake was reported low similar to our study where only 7.3% got flesh foods. In our study, legumes and nuts were served for only 13% of the children. Therefore, it is a potential to improve protein-rich food intake using both animal and plant sources. However, there were food taboos described in the 70-ties, which could not be confirmed in our study, thus, there may be potential for recommendation of more nutritious complementary diets

Risk factors of linear growth faltering (stunting)

The prevalence of stunting in our study was similar to EDHS (2016) from the Southern region [4]. However, our study subjects were children under the age of two years from a typical rural area; the EDHS report had included children under the age of five years from both urban and rural areas. This indicates that stunting persists from the early ages. EDHS (2016) reported that stunting had its peak at 24 months; similarly, our finding supports that older children were more affected by stunting. This finding has its implication for indicating that the critical period for prevention of stunting is before the age of two years.

Being male was associated with a decrease in the length-for-age z-score almost by half which is consistent with the EDHS (2016) report and other studies [22, 38–41]. A study done in four regions of Ethiopia support our finding; stunting is common among male children than girls [42] However, there are studies reporting no association between stunting and child's sex [43–45], and that boys are at a lower risk than girls [46]. The observed sex differences have not yet been fully explained, neither with biological, dietary, or cultural differences. One suggested explanation from a study in Senegal was that boys end exclusive breastfeeding earlier than girls in the recommended exclusive breastfeeding period of the first six months [47]. Our study did not collect data to assess this and we suggest further study to deeply investigate the nutritional status in relation to gender differences.

Similarly, haemoglobin level of the child was positively associated with the linear growth of a child. We have found that each unit of haemoglobin level was associated with an increase of LAZ score by 0.21. Besides, 27% of the children aged 0–24 months were anaemic and stunted. This relationship has recently been described by other child health studies from southern

Ethiopia [48, 49], which suggested looking at anaemia and stunting as syndemic needing similar preventive strategies. Another study done in India and Peru support our finding; positive association between linear growth failure and low haemoglobin level [50].

In our study, only 25% of the households were food secure. Even though the older studies from the study area did not report on household food insecurity, recent studies from the region agree with our findings [51, 52]. In our study, an increase in the household food insecurity score was associated with a decrease in LAZ scores. This finding is consistent with a recent study done in other regions of Ethiopia [53]. Actions are needed to improve the situation where only a quarter feel food secure. Maternal factors; height and haemoglobin did not demonstrate association in our study, however maternal height was a risk factor in previous studies [54].

Strengths of the study

Our study was a community-based study, with random selection of households, reaching less accessible rural areas. The sampling frame was prepared by a baseline survey conducted prior to the main data collection. Comprehensive data were collected at an individual level (the young child and the mother) and the household level. All the data collectors and supervisors were fluent speakers of the local language, *Sidaamu Afoo* which was used for the interview. Simulated practical training was included in the training session of data collectors and supervisors.

Limitations of the study

Our study may be subject to information bias; self-reported data like age, birth weight, breastfeeding initiation time, and dietary recalls may create informational bias. Measurement bias is also expected to exist. Replacement of some households who left the area before enrolment may create a selection bias. Almost 8% of the visited households were excluded from data analysis due to child age uncertainty and incomplete key data necessary for our analysis. This may be considered relatively high but indicates challenges in capturing such type of data in a rural setting with low level of education, a different calendar system, and lack of health records. However, we performed the sample size calculation by considering a 10% non-response rate. Also, there may be residual confounding not addressed particularly including long term morbidity patterns such as parasites and immune deficiency.

Conclusion

This study demonstrated that there is high burden of chronic child undernutrition. According to older studies from the area, there have been limited improvements over decades. It also identified changes in the food system of the community where the cultivation and utilization of ensete is being replaced by maize. Older child age, male sex, lower haemoglobin levels of the child, and household food insecurity were associated with lower linear growth. There is a need to strengthen efforts to improve household food security, young children's complementary diet and economic status with considerable focus in rural districts while monitoring growth, diets, and health in young children. Furthermore, promoting the environmental benefit of ensete and availing modern technologies for ensete cultivation and processing can be a strategic approach.

Supporting information

S1 Table. Descriptive findings of continuous variables among children and their mothers in Dale district, Ethiopia, 2018.
(PDF)

S1 File. Raw data used to constract Tables 1–5 in Dale district, Ethiopia, 2018.
(SAV)

S2 File. Appendix (Questionnaire; English version).
(PDF)

S3 File. Appendix (Questionnaire; Sidaamu Afoo version).
(PDF)

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References

1. World Health Organization (2006) Child Growth Standards based on length/height, weight and age, in *Acta paediatrica (Oslo, Norway: 1992) Supplement*. pp. 76.
2. Food and Agriculture Organization (2014) FAO. *The State of Food Insecurity in the World*. 2014. www.fao.org/3/a-i4030e.pdf.

3. *Ethiopian Public Health Institure and ICF (2019) Ethiopia mini demographic and health survey 2019: key indicators*. Rockville, Maryland, USA: EPHI and ICF.

4. Central Statstical Agency and ICF (2016) Ethiopia Demographic and Health Survey 2016: Key Indicators Report. *International Journal for Equity in Health*. p. 32–45.

5. Alemayehu M, Meskele M, Alemayehu B (2019) Prevalence and correlates of anemia among children aged 6–23 months in Wolaita Zone, *Southern Ethiopia*. 14: e0206268. https://doi.org/10.1371/journal.pone.0206268.

6. Abebe Z, Tariku A, Bikes GA, Wassie MM, Gonete KA, et al. (2019) Poor child complementary Feeding Practices in northwest Ethiopia: Finding from the Baseline Survey of Nutrition Project, 2016. Ital J Pediatr45: 154. https://doi.org/10.1186/s13052-019-0747-2.

7. Yemata G (2020) Ensete ventricosum: A Multipurpose Crop against Hunger in Ethiopia. ScientificWorldJournal, 2020: 6431849. https://doi.org/10.1155/2020/6431849.

8. Mohammed B, Gabel M, Karlsson LM (2013) Nutritive values of the drought tolerant food and fodder crop enset. African Journal of Agricultural Research8: 2326–2333. https://doi.org/10.5897/AJAR12.1296.

9. Nurfeta A, Tolera A, Eik LO, Sundstøl F (2008) Yield and mineral content of ten enset (Ensete ventricosum) varieties. Trop Anim Health Prod 40: 299–309. https://doi.org/10.1007/s11250-007-9095-0 PMID: 18557193

10. Selinus R, Gobezie A, Vahlquist B (1971) Dietary studies in Ethiopia. 3. Dietary pattern among the Sidamo ethnic group. A study on villagers in the enset monoculture area in S. *Ethiopia with special attention to the situation in young children*. Acta Societatis Botanicorum Poloniae76: 158–178.

11. Sonko A (2016) Assessment of dietary practice and anthropometric status of pregnant women in Aleta Chuko Woreda Southern Nations, Nationalities and People's Region/SNNPR/, Ethiopia. J Epidemiol Public Health Rev 1: 1–9. https://doi.org/10.16966/2471-8211.102.

12. Borrell JS, Biswas MK, Goodwin M, Blomme G, Schwarzacher T, et al. (2019) Enset in Ethiopia: a poorly characterized but resilient starch staple. Ann Bot 123: 747–766. https://doi.org/10.1093/aob/mcy214.

13. Borrell JS, Goodwin M, Blomme G, Jacobsen K, Wendawek AM, et al. (2020) Enset-based agricultural systems in Ethiopia: A systematic review of production trends, agronomy, processing and the wider food security applications of a neglected banana relative. Plants, People, Planet2: 212–228. https://doi.org/10.1002/ppp3.10084.

14. Quinlan RJ, Quinlan MB, Dira S, Caudell M, Sooge A, et al. (2015), Vulnerability and resilience of Sidama enset and maize farms in Southwestern Ethiopia. Journal of Ethnobiology35: 314–336. https://doi.org/10.2993/etbi-35-02-314-336.1.

15. Quinlan RJ, Dira SJ, Caudell M, Quinlan MB (2016) Culture and psychological responses to environmental shocks: Cultural ecology of Sidama impulsivity and niche construction in southwest Ethiopia. Current Anthropology. https://doi.org/10.1086/688213.

16. Areru HA, Dangisso MH, Lindtjørn B (2020) *Births and deaths in Sidama in southern Ethiopia: findings from the 2018 Dale-Wonsho Health and Demographic Surveillance System (HDSS)*. 13: 1833511. https://doi.org/10.1080/16549716.2020.1833511.

17. Oot L, Sethuraman K, Ross J, Sommerfelt A (2016) The Effect of Chronic Malnutrition (Stunting) on Learning Ability, a Measure of Human Capital: A Model in PROFILES for Country-Level-Advocacy. Food and Nutrition technical Assistance3: 1–8.

18. Woldehanna T, Behrman JR, Araya MW (2017) The effect of early childhood stunting on children's cognitive achievements: Evidence from young lives Ethiopia. Ethiopian Journal of Health Development31: 75–84. PMID: 29249889

19. Wolde T, Belachew T (2019) Chronic undernutrition (stunting) is detrimental to academic performance among primary schools of adolescent children: a randomized cross sectional survey in Southern Ethiopia. BMC Res Notes12: 142. https://doi.org/10.1186/s13104-019-4160-0 PMID: 30876451

20. Galato ZG (2020) Impacts of Productive Safe Southern Ethiopia. International Journal of Current Research Key Words.

21. Martorell R, Zongrone A (2012) Intergenerational influences on child growth and undernutrition. Paediatr Perinat Epidemiol 26 Suppl 1: 302–14. https://doi.org/10.1111/j.1365-3016.2012.01298.x.

22. Medhin G, Hanlon C, Dewey M, Alem A, Tesfaye F, et al. (2010) Prevalence and predictors of undernutrition among infants aged six and twelve months in Butajira, Ethiopia: the P-MaMiE Birth Cohort. BMC Public Health10: 27. https://doi.org/10.1186/1471-2458-10-27 PMID: 20089144

23. Dessie ZB, Fentie M, Abebe Z, Ayele TA, Muchie KF (2019) Maternal characteristics and nutritional status among 6–59 months of children in Ethiopia: further analysis of demographic and health survey. BMC pediatrics19: 1–10. https://doi.org/10.1186/s12887-019-1459-x PMID: 30894145

24. Sullivan KM, Mei Z, Grummer-Strawn L, Parvanta I (2008) Haemoglobin adjustments to define anaemia. Tropical Medicine & International Health13: 1267–1271. https://doi.org/10.1111/j.1365-3156.2008.02143.x.
25. Neufeld L, García-Guerra A, Sánchez-Francia D, Newton-Sánchez O, Ramírez-Villalobos MD, et al. (2002) Hemoglobin measured by Hemocue and a reference method in venous and capillary blood: a validation study. Salud pública de México44: 219–227. https://doi.org/10.1590/s0036-36342002000300005 PMID: 12132319
26. Sinhababu A, Mukhopadhyay DK, Panja TK, Saren AB, Mandal NK, et al. (2010) Infant-and young child-feeding practices in Bankura district, West Bengal, India. Journal of health, population, and nutrition28: 294. https://doi.org/10.3329/jhpn.v28i3.5559 PMID: 20635641
27. Gebreyesus SH, Lunde T, Mariam DH, Woldehanna T, Lindtjørn B (2015) Is the adapted Household Food Insecurity Access Scale (HFIAS) developed internationally to measure food insecurity valid in urban and rural households of Ethiopia? BMC Nutrition1: 2.
28. Swindale A, Bilinsky P (2006) Development of a universally applicable household food insecurity measurement tool: process, current status, and outstanding issues. The Journal of nutrition136: 1449S–1452S. https://doi.org/10.1093/jn/136.5.1449S.
29. Coates J, Swindale A, Bilinsky P (2007) *Household Food Insecurity Access Scale (HFIAS) for measurement of food access: indicator guide: version 3*.
30. Pirani E(2014) Wealth index. Encyclopedia of Quality of Life and Well-Being Research. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-0753-5_3202.
31. Vyas S, Kumaranayake L (2006) Constructing socio-economic status indices: how to use principal components analysis. Health Policy and Planning21: 459–468. https://doi.org/10.1093/heapol/czl029 PMID: 17030551
32. Helsinki WMADo (2013) World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. Jama310: 2191–4.
33. Branca F, Pastore G, Demissie T, Ferro-Luzzi A (1993) The nutritional impact of seasonality in children and adults of rural Ethiopia. European journal of clinical nutrition47: 840–850.
34. Mellisse BT, van de Ven GW, Giller KE, Descheemaeker K (2018) Home garden system dynamics in Southern Ethiopia. Agroforestry Systems 92: 1579–1595. https://doi.org/10.1007/s10457-017-0106-5.
35. World Health Organization (2005) *Guiding principles for feeding non-breastfed children 6–24 months of age*: World Health Organization.
36. Riley LK, Rupert J, Boucher O (2018) Nutrition in Toddlers. Am Fam Physician98: 227–233. PMID: 30215978
37. Tolosa T, Verbeke J, Piepers S, Tefera M, Getachew Y, et al. (2016) Milk production, quality, and consumption in Jimma (Ethiopia): Facts and producers', retailers', and consumers' perspectives. Prev Vet Med124: 9–14. https://doi.org/10.1016/j.prevetmed.2015.12.016.
38. Tafesse T, Yoseph A, Mayiso K, Gari T (2021) Factors associated with stunting among children aged 6–59 months in Bensa District, Sidama Region, South Ethiopia: unmatched case-control study. BMC pediatrics21: 1–11. https://doi.org/10.1186/s12887-021-03029-9 PMID: 34872503
39. Wamani H, Astrøm AN, Peterson S, Tumwine JK, Tylleskär T (2007) Boys are more stunted than girls in sub-Saharan Africa: a meta-analysis of 16 demographic and health surveys. BMC Pediatr7: 17. https://doi.org/10.1186/1471-2431-7-17 PMID: 17425787
40. Teshome B, Kogi-Makau W, Getahun Z, Taye G (2009) Magnitude and determinants of stunting in children underfive years of age in food surplus region of Ethiopia: the case of west gojam zone. Ethiopian Journal of Health Development23. https://doi.org/10.4314/ejhd.v23i2.53223.
41. Jiang Y, Su X, Wang C, Zhang L, Zhang X, et al. (2015) Prevalence and risk factors for stunting and severe stunting among children under three years old in mid-western rural areas of C hina. Child: care, health and development41: 45–51. https://doi.org/10.1111/cch.12148.
42. Hirvonen K, Wolle A, Laillou A, Vinci V, Chitekwe S, et al. (2021) Child growth faltering dynamics in food insecure districts in rural Ethiopia. Maternal & child nutrition e13262. https://doi.org/10.1111/mcn.13262 PMID: 34523809
43. Woldie YT, Belachew T, Hailu D, Teshome T, Gutema H (2015) Prevalence of stunting and associated factors among under five children in Wondo Genet Woreda, Sidama Zone, Southern Ethiopia. International Journal of Medical and Health Sciences Research2: 36–49. http://dx.doi.org/10.18488/journal.9/2015.2.2/9.2.36.49.
44. Gari T, Loha E, Deressa W, Solomon T, Lindtjørn B (2018) Malaria increased the risk of stunting and wasting among young children in Ethiopia: Results of a cohort study. PLoS One 13: e0190983. https://doi.org/10.1371/journal.pone.0190983 PMID: 29324840

45. Belayneh M, Loha E, Lindtjørn B (2020) 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* 1–26. https://doi.org/10.1080/03670244.2020.1789865.

46. Abeway S, Gebremichael B, Murugan R, Assefa M, Adinew YM (2018) Stunting and its determinants among children aged 6–59 months in northern Ethiopia: a cross-sectional study. Journal of nutrition and metabolism 2018. https://doi.org/10.1155/2018/1078480.

47. Bork KA, Diallo A (2017) Boys are more stunted than girls from early infancy to 3 years of age in rural Senegal. The Journal of nutrition147: 940–947. https://doi.org/10.3945/jn.116.243246 PMID: 28298540

48. Orsango AZ, Habtu W, Lejisa T, Loha E, Lindtjørn B, Engebretsen IMS (2021) Iron deficiency anemia among children aged 2–5 years in southern Ethiopia: a community-based cross-sectional study. PeerJ9: e11649. https://doi.org/10.7717/peerj.11649 PMID: 34249504

49. Orsango AZ, Loha E, Lindtjørn B, Engebretsen IMS (2021) Co-morbid anaemia and stunting among children 2–5 years old in southern Ethiopia: a community-based cross-sectional study. BMJ Paediatrics Open5: e001039. https://doi.org/10.1136/bmjpo-2021-001039.

50. Gosdin L, Martorell R, Bartolini RM, Mehta R, Srikantiah S, et al. (2018) *The co-occurrence of anaemia and stunting in young children*. 14: e12597. https://doi.org/10.1111/mcn.12597.

51. Tessema M, Belachew T, Ersino G (2013), Feeding patterns and stunting during early childhood in rural communities of Sidama, South Ethiopia. Pan African Medical Journal14. https://doi.org/10.11604/pamj.2013.14.75.1630 PMID: 23646211

52. Desalegn BB, Jagiso B (2020) Low diet diversity and its associated factors among the mothers and their children in agroforestry land use systems of Sidama, Ethiopia: A community-based cross-sectional study. Cogent Food & Agriculture6: 1818367. https://doi.org/10.1080/23311932.2020.1818367.

53. Berra WG (2020) Household Food Insecurity Predicts Childhood Undernutrition: A Cross-Sectional Study in West Oromia (Ethiopia). J Environ Public Health, 2020: 5871980. https://doi.org/10.1155/2020/5871980 PMID: 32211049

54. Gibson RS, Abebe Y, Hambidge KM, Arbide I, Teshome A, et al. (2009) Inadequate feeding practices and impaired growth among children from subsistence farming households in Sidama, Southern Ethiopia. Matern Child Nutr5: 260–75. https://doi.org/10.1111/j.1740-8709.2008.00179.x.djk

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Anaemia, anthropometric undernutrition and associated factors among mothers with children younger than 2 years of age in the rural Dale district, southern Ethiopia: A community-based study

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Abstract

Mothers in resource-poor settings are affected by different forms of undernutrition. However, the nutritional status of mothers in rural areas, particularly after delivery, is not well documented. This study assessed haemoglobin levels and body mass index (BMI) of mothers with children below 2 years of age in a rural district of southern Ethiopia. Factors associated with low haemoglobin levels and low BMI were analysed. A community-based cross-sectional study was conducted among 931 mother-child pairs. Structured and standard questionnaires were used to collect data on background information, 24 h dietary recalls, and household food insecurity. Anthropometric and haemoglobin level assessments were performed. Anaemia was defined as haemoglobin levels below 12.0 g/dl, and anthropometric undernutrition was defined as a BMI <18.5 kg/m^2. Multilevel linear regression was used to determine associations. Out of 931 mothers, 12.8% were anaemic and 12.6% had a BMI <18.5 kg/m^2. The prevalence of minimum dietary diversity was 37.8%. The majority (78.5%) of the households were food insecure. Weight (β 0.02; 95% CI: 0.003–0.03), dietary diversity (β 0.08; 95% CI: 0.03–0.12) and secondary school attendance (β 0.34; 95% CI: 0.08–0.59) were associated with the mothers' haemoglobin level. Dietary diversity (β 0.08; 95% CI: 0.01–0.16) and household's wealth (β 0.6; 95% CI: 0.27–0.94) were associated with the mothers' BMI. Findings suggest that education and community-based nutrition interventions must be strengthened to ensure household food security. Implementation of the national food-based strategies should be considered, to improve the dietary diversity and nutritional status of mothers.

KEYWORDS
anaemia, anthropometry, Dale district, dietary diversity, Ethiopia, food insecurity, undernutrition

1 | INTRODUCTION

Maternal undernutrition is a major public health problem and contributes to an intergenerational cycle of undernutrition (Farah et al., 2019). In addition to poverty-related factors affecting the general population, women in the reproductive age group are challenged by the physiology of menstruation and childbearing (Were et al., 2020). Childbearing processe—pregnancy, delivery and lactation—are likewise nutritionally demanding processes that impose several risks on the mother and the child. Examples of major severe outcomes could include intrauterine growth failure, low birth weight, anaemia in the mother and the child, susceptibility to infection (Christian et al., 2015; Patel et al., 2018) and ultimately maternal and child mortality (Christian et al., 2015).

Ethiopia, as a resource-poor country, has a high burden of maternal undernutrition (Zewdie & Fage, 2021). Most settings in Ethiopia experience a shortage of food (Birhanu & Tadesse, 2019; Juju & Sekiyama, 2018), as well as low health service access and utilisation (Areru et al., 2021; Borde et al., 2020). Moreover, there is limited access to a safe water supply and sanitation (Azage et al., 2020; Girum & Wasie, 2017). Studies in Ethiopia have shown that women in the reproductive age group have multiple pregnancies, often close together, and inadequate dietary intake (Aychiluhm et al., 2020; Mamo & Dagnaw, 2021). In 2019, 43% of women had attended at least the four recommended antenatal care (ANC) visits during the most recent pregnancy, and 28% within the first trimester. The corresponding numbers were 32% and 20% in 2016 (Centeral Statstical Agency CSA & ICF, 2016; Ethiopian Public Health Institute EPHI & ICF, 2019). The proportion of institutional delivery in Ethiopia is also low (26% at the national level) (Centeral Statstical Agency CSA & ICF, 2016), making mothers more vulnerable to complications from pregnancy and delivery (Anshebo et al., 2020). A study done in southern Ethiopia reported health service utilisation was 11 times lower among the rural community than in the urban (Areru et al., 2021). The same study also reported that ANC attendance (45%) and delivery service utilisation (41%) were better than post-natal service utilisation (14%).

Body mass index (BMI) is an important indicator of a mother's nutritional status. Studies documented that both being underweight (BMI <18.5 kg/m^2) and overweight (BMI ≥25 kg/m^2) among mothers are associated with adverse outcomes of childbearing (Christian et al., 2015; Félix-Beltrán et al., 2021). Even though there is an increasing rate of obesity and being overweight among mothers (Jaacks et al., 2017; Kaldenbach et al., 2021; Were et al., 2020), maternal anthropometric undernutrition is still a great concern in many resource-poor settings (Berihun et al., 2017; Kenea et al., 2018). Particularly in rural areas of Ethiopia, mothers are affected by anaemia and other forms of undernutrition before pregnancy, during pregnancy and after delivery.

The prevalence of anaemia among mothers aged 15–49 years was reported at 24% in 2016 (Centeral Statstical Agency CSA & ICF, 2016). Based on the 2019 Ethiopian Demographic and Health Survey (EDHS) report, the percentage of pregnant mothers who took iron supplements for at least 90 days increased to 11% from 5% in 2016 (Ethiopian Public Health Institute EPHI & ICF, 2019). The prevalence of thinness (BMI <18.5 kg/m^2) among mothers aged 15–49 years was also reported at 22% in 2016. Even though minimal improvements are documented at the national level regarding most maternal health indicators, women in the rural and less privileged areas are more likely to be nutritionally challenged. There is limited information on the magnitude of anaemia and anthropometric undernutrition among mothers after delivery in rural areas. The aim of this study was to assess the prevalence of anaemia and undernutrition, specifically low BMI, among mothers with children younger than 2 years of age, and to determine the prevalence of minimum dietary diversity. We also aimed to describe factors associated with low haemoglobin levels and low BMI in the Dale district of the Sidama region in southern Ethiopia.

Key messages

- Anaemia and underweight were less prevalent among mothers with young children in the rural Dale district, southern Ethiopia, than the national report of the Ethiopian Demographic and Health Survey in 2016.
- Dietary diversity is positively associated with haemoglobin level and body mass index among mothers with children younger than 2 years of age.
- The existing nutrition interventions such as the Productive Safety Net Programme need strengthening, to improve the sustained food access to rural households.
- Planing and implementing community-based small-scale activities, such as school gardening, and fish and poultry farming, to ensure the availability and affordability of nutritious foods.

2 | METHODS AND MATERIALS

2.1 | Study design and setting

In 2018, a community-based cross-sectional study was conducted in seven rural *kebeles* of the Dale district, which is located in the Sidama region in southern Ethiopia. A *kebele* is the smallest administrative unit in Ethiopia. Dale is one of the 19 districts in the Sidama region. In 2017, the total population of the district was about 270,000 people, living in 36 rural and two urban *kebeles*. The main town of the district, Yirga Alem, is located 320 km from Addis Ababa. In the Dale district, there are 33 health posts, 10 health centres, and 1 hospital (Yirga Alem general hospital). At least 1 health post was found in all the seven *kebeles* included in this study. People living in the area

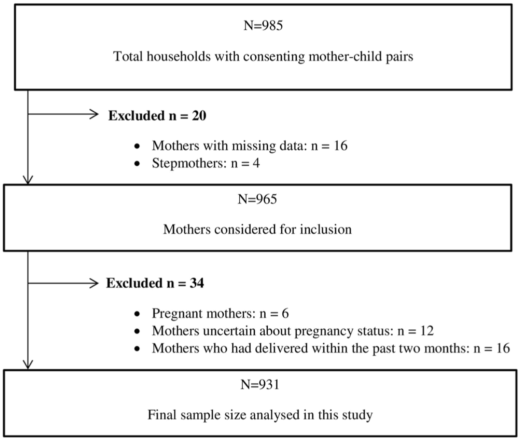

FIGURE 1 Study profile which presents exclusion of study subjects with the reasons for exclusion

were farmers, cultivating ensete (*Ensete ventricosum*), maize, kale, cabbage and haricot beans. Coffee, khat (*Catha edulis*) and fruits are grown in the area as cash crops. The community also keeps livestock, such as cows, goats and sheep.

2.2 | Study participants

Of the 985 mother-child pairs enroled in our larger study, 931 mothers (aged 15–49 years, who had a child younger than 2 years, and were not pregnant, and had not delivered within the past 2 months) were included in this study. A study profile is given in Figure 1.

2.3 | Sample size estimation and sampling procedures

The sample size was calculated using the OpenEpi version 3.01 (Dean et al., 2013) statistical software. We assumed a 95% confidence level, 4% precision and 50% prevalence for a child health condition (stunting), as explained in a parallel paper on child health (a paper under peer review). By considering 1.5 for the design effect and 10% for the nonresponse rate, the final sample size calculated was 990 households with mother-child pairs.

All households with at least one mother aged 15–49 years and one child under the age of 2 years were listed from the seven rural *kebeles*. Using probability proportional to size, households were selected from each *kebele*. As a replacement for eligible participants who had left before potential enrolment, the next household with a similar mother-child pair was taken. A total of 89 replacements were made because of the official displacement of households from two of the *kebeles* during our data collection period.

2.4 | Data collection

Pre-tested questionnaires were used to collect background household information and the sociodemographic, reproductive and dietary information of mothers. Face-to-face interviews were conducted in the local language, *Sidaamu Afoo*. All the questionnaires used were prepared in English and translated first to Amharic (the official language) and then to *Sidaamu Afoo*. Back translations were performed to check the consistency. Six data collectors (nurses and laboratory technicians) and two supervisors were recruited and trained on interview techniques and measurement procedures. Written consent was obtained before starting the interview, and finger stamps were used for illiterate respondents. In situations where the mother preferred for her husband to answer some of the questions related to her and the household characteristics, we obtained such information from the husband. All measurements were taken for each woman after the interview session.

2.5 | Study variables

The outcome variables in our study were anaemia and anthropometric undernutrition. Anaemia was defined as a haemoglobin level of less than 12.0 g/dl (World Health Organisation WHO, 2011). Anthropometric undernutrition was defined as having a BMI of less than 18.5 kg/m^2 (World Health Organisation WHO, 2019); this state has various descriptions such as 'thinness' and 'underweight'. In short, it reflects a body shape with low weight for its height and is generally an accepted indicator for anthropometric undernutrition at group level. The independent variables were the mother's age, educational status, number of pregnancies, age at first pregnancy, place of last delivery, current use of family planning and dietary diversity scores. The total number of people living in the household, household food insecurity and the household's wealth status were also included.

2.5.1 | Anthropometric measurements

The weight, height and mid-upper arm circumference (MUAC) of the mothers were taken at their home or a nearby place suitable for the measuring instruments. Portable digital SECA weight scales (Seca 874; SECA GmbH) were used to measure the weight of mothers to the nearest 0.1 kg. The mothers' height was measured using portable SECA stadiometers (Seca 213; SECA GmbH) to the nearest 0.1 cm. Mothers were asked to remove extra clothing and shoes before standing on the scales or on the stadiometers. The mother's MUAC was measured using a flexible nonelastic adult MUAC measuring tape. The weight, height and MUAC were taken twice to minimise measurement errors. The average weight, height and MUAC were calculated during the data entry and used for analysis. The BMI of mothers was computed in SPSS by dividing weight in kilograms by the height in metres squared.

2.5.2 | Haemoglobin level measurements

The mothers' haemoglobin levels were measured with HemoCue HB 301 machines using capillary blood samples obtained by a finger-prick. Haemoglobin levels were adjusted for altitude at 2000 m, since most of our study sites were from 1750–2250 m above sea level (Sullivan et al., 2008).

2.5.3 | The 24 h dietary recall

A list-based method was used to collect the mothers' 24 h dietary recall. The enumerator asked the mother whether she had or had not eaten the listed food items during the past 24 h. Data on 10 food groups (cereals, roots and tubers, legumes and nuts, meat (organ meat, flesh meat and poultry), fish, eggs, milk and dairy products, dark green leafy vegetables, orange-coloured fruits and vegetables and other fruits and vegetables) was collected. The use of fats and oils, sweets and fortified or commercial foods was also assessed. The mother was asked if she had eaten any foods not included in the list. Food groups the mother had eaten were scored 'one', and food groups she had not eaten were scored 'zero'. The dietary diversity score of the mother was obtained by adding up the scores of the 10 food groups. The prevalence of minimum dietary diversity was determined by dividing the total number of mothers with a score of five or higher by the total number of mothers who participated in the study.

2.5.4 | Household food insecurity

Household food insecurity was assessed using the Household Food Insecurity Access Scale (HFIAS), a tool validated for use in Ethiopia (Gebreyesus et al., 2015). The tool comprises nine questions that measure the three domains of food insecurity: uncertainty of food supply, poor dietary quality and inadequate food intake (Gebreyesus et al., 2015; Swindale & Bilinsky, 2006). Information was collected about the households' experiences of the nine situations in the 4 weeks preceding this study. All 'yes' responses were followed by the question: 'How many times in the last 4 weeks?' The frequency of occurrence was then scored 'one' if it was once or twice; 'two' if it was three to ten times; and 'three' if it was more than ten times. All 'no' responses to the nine food insecurity questions were scored 'zero' for the frequency of occurrence. The total HFIAS score ranged from 0 to 27, where higher values indicated more food insecurity. Households were classified into four food insecurity levels based on the Food and Nutrition Technical Assistance classification guideline (Coates et al., 2007). The prevalence of food security, mild food insecurity, moderate food insecurity and severe food insecurity was determined.

2.5.5 | Wealth index

A household's economic status was determined using principal component analysis in SPSS. The possession of household assets, such as radio, television and mobile phone, and the ownership of livestock, such as cows, sheep, goats, donkeys and hens, was assessed. Housing materials and sources of drinking water were also included to compute the wealth index. The Kaiser–Meyer–Olkin sampling adequacy test was 62%, with a significant (<0.001) Bartlett's test of sphericity. Four out of nine components had an eigenvalue greater than one. Finally, households were ranked into three economic statuses: lower, middle and upper.

2.6 | Data quality control

Measuring instruments were calibrated and cleaned on a regular basis. Practical sessions on measurement procedures were included while training the data collectors. Close supervision was applied throughout the data collection period. All questionnaires were checked for completeness, and any missing information was recaptured whenever possible. The data was double-entered and validated using the EpiData version 3.1 (EpiData Association) software. Conducting the interviews in the local language was an additional strategy that we applied.

2.7 | Statistical analysis

The data was described using SPSS version 25 (IBM Corp.). STATA version 15.1 (Stata Corp.) was used to build the regression models. Descriptive statistics such as frequencies, percentages and means were used to present the continuous and categorical variables. Bivariable linear regressions were computed before running the multivariable linear regression. All variables with a $p < 0.25$ in the bivariable linear regression were included in the multivariable linear regression. The calculated intracluster coefficient was 5.6% (ICC = 0.056); thus, all the regression analyses were performed by adjusting for clustering at the *kebele* level. Multicollinearity between the independent variables was checked before running the multivariable linear regression. The adjusted beta (β) coefficients, with 95% confidence intervals (CI), were used to determine associations between the predictor variables and the outcome variables. The level of significance was set at $p < 0.05$. Correlations between each of the nutritional status indicators: haemoglobin level, BMI and MUAC were also checked. Pearson bivariate correlation coefficients were used to describe correlations between each of these variables.

TABLE 1 Household background and characteristics of mothers in rural Dale district, Ethiopia, 2018 (*N* = 931, unless otherwise specified)

Variable	Number	%
People living in the household		
Less than five	481	51.7
Five and above	450	48.3
Wealth index		
Lower	285	30.6
Middle	336	36.1
Upper	310	33.3
Household food insecurity		
Food secure	200	21.5
Mild food insecurity	230	24.7
Moderate food insecurity	364	39.1
Severe food insecurity	137	14.7
Age of the mother		
15–24 years	294	31.6
25–34 years	541	58.1
35 years and above	96	10.3
Education		
No education	159	17.1
Primary school	422	45.3
Secondary school and above	350	37.6
Total number of pregnancies		
One	270	29.0
Two or three	396	42.5
Four or five	223	24.0
Six and above	42	4.5
Age at first pregnancy (922)		
Under 18 years	239	25.9
18 years and above	683	74.1
Place of last delivery (923)		
Home	357	38.7
Health institution	566	61.3
Current use of FP method (929)		
Yes	866	93.2
No	63	6.8
Child-bearing complication ever faced		
Yes	39	4.2
No	892	95.8
Illness in the past 2 weeks		
Yes	31	3.3
No	900	96.7

3 | RESULTS

3.1 | Background information and maternal characteristics

Of the 931 mothers included in the analysis, the majority (59.9%) were aged 25–34 years; 45.3% (422) had attended primary school and 37.6% (350) secondary school (Table 1). More than a third of the mothers had had two or three pregnancies and one-quarter of mothers were under 18 years during their first pregnancy. Home delivery was practiced by 38.3% (357) mothers during the last delivery, and over 90% of the mothers had reported current use of any family planning method. Mothers who reported illness in the 2 weeks prior to our study comprised 3.3% (31) of mothers. Childbearing complications ever faced were reported by 4.2% (39) of mothers, and bleeding was the most common complication faced (14 out of 39 mothers). More than half (51.7%) of the mothers were from households with fewer than five members, and 78.5% of mothers were living in food-insecure households. About 38.8% (361) of the total households were using piped water located at the village level, and the rest of the households were using springs and water pits.

3.2 | Dietary diversity of mothers

Based on a 24 h dietary recall, the mean dietary diversity score of mothers was 4.5 (95% CI: 4.3–4.6). More than half, 62.2% (579 mothers), had a dietary diversity score below five out of 10. During the past 24 h, cereals (97.9%) were the most commonly consumed food group, and meat (20.3%) was the least (Table 2). Nobody ate fish.

3.3 | Household food insecurity

The mean household food insecurity access score was 4.0 (95% CI: 3.8–4.2), and more than three-quarters (78.5%) of the total households were food insecure. Nearly 15% (137) of the total households were severely food insecure (Table 1). The majority (61.1%) of the households had experienced eating a limited variety of food within the past 4 weeks. More than half (56.3%) of the households reported that they were worried about having enough food for the household. Less than 11% of households had

TABLE 2 The 24 h food consumption and dietary diversity of mothers in rural Dale district, Ethiopia, 2018

Food groups	Consumed in the past 24 h Number (N = 931)	%
Cereals and grains	911	97.9
Roots and tubers	761	81.7
Legumes and nuts	224	24.1
Milk and dairy products	576	61.9
All meats including organ meats	189	20.3
Eggs	270	29.0
Green leafy vegetables	835	89.7
Orange coloured fruits	369	39.6
Dietary diversity of the mother		
<Five food groups	579	62.2
≥Five food groups	352	37.8

Note: None of the mothers ate fish in the previous month.

experienced the three severe food insecurity situations (Supporting Information: Table S1).

3.4 | Nutritional and clinical characteristics

The prevalence of anaemia was 12.8% (119 mothers) and the prevalence of underweight was 12.6% (117 mothers). Out of 931 mothers, 30.8% (287) had a MUAC less than 23 cm (Table 3). Of the 931 mothers, 13.6% (127) weighed below 45 kg and 10.5% (98) were below 150 cm tall. The mean haemoglobin level of mothers was 13.2 (95% CI: 13.1–13.3), and the mean BMI of mothers was 20.7 (95% CI: 20.6–20.9) kg/m^2. Continuous variables are given in Table 4.

3.5 | Correlation between haemoglobin level, BMI and MUAC

There was a medium positive correlation (0.549) between haemoglobin level, BMI, and MUAC (Supporting Information: Table S2).

3.6 | Factors associated with haemoglobin level and BMI

The unadjusted and adjusted linear regression coefficients are presented in Table 5. Weight, dietary diversity score and educational status of the mother were independently and positively associated with the haemoglobin level. For each kilogram increase in the weight of the mother, haemoglobin level increased by 0.02 g/dl (β 0.02; 95% CI: 0.003–0.03). As the dietary diversity score increased by one, haemoglobin level increased by 0.08 g/dl (β 0.08; 95% CI: 0.03–0.12). In addition, secondary school attendance was positively associated

TABLE 3 Nutritional status of mothers with a child less than 2 years of age in rural Dale district, Ethiopia, 2018 (*N* = 931)

Variable	Number	%
Haemoglobin level (g/dl)		
<12.0	119	12.8
≥12.0	812	87.2
Body mass index		
<18.5	117	12.6
18.5–24.9	791	84.9
25.0–29.9	21	2.3
>30.0	2	0.2
Mid-upper arm circumference (cm)		
<23	287	30.8
≥23	644	69.2

with the haemoglobin level of the mother (β 0.34; 95% CI: 0.08–0.59). Likewise, the dietary diversity score and the upper wealth index of the household were positively associated with the BMI of the mother. For each unit increase in the dietary diversity score, BMI increased by 0.08 kg/m^2 (β 0.08; 95% CI: 0.01–0.16). Mothers from households with the upper wealth index had a BMI increase of 0.6 kg/m^2 (β 0.6; 95% CI: 0.27–0.94).

4 | DISCUSSION

Our study assessed the prevalence of anaemia and underweight among mothers with children under 2 years of age in the rural Dale district, southern Ethiopia. In our study, 12.8% of the mothers were anaemic, and 12.6% were underweight. The majority of the mothers had low dietary diversity, and more than three-quarters of the households were food insecure. Dietary diversity, weight and mother's educational level were independently positively associated with haemoglobin level of the mother. In addition, dietary diversity and household's wealth status were independently positively associated with the BMI of the mother.

The prevalence of anaemia in our study was lower than the national report of the EDHS in 2016 (24%) (Centeral Statstical Agency CSA & ICF, 2016). Whereas the EDHS, as a national report, had included all women of reproductive age from urban and rural areas, our study assessed mothers who had children younger than 2 years in rural areas only. The mean haemoglobin level in our study (13.2 g/dl) was higher than the mean in a study that assessed the immediate post-partum anaemia in northwest Ethiopia (12.4 g/dl) (Abebaw et al., 2020). The difference may be due to the time when the mother was assessed after delivery. In our study, mothers who had children under 2 years of age were included, and we excluded those who had given birth in the previous 2 months, whereas the other study assessed mothers immediately after delivery. The study setting could also partially explain the difference; our study was

TABLE 4 Clinical and nutritional characteristics, Ethiopia, 2018 (continuous variables)

Variable	*N*	Mean (95% confidence interval)	Standard deviation	Median (inter quartile range)	Minimum	Maximum
Mother's age	931	26.9 (26.5–27.2)	5	26 (6)	16	45
Age at first pregnancy	922	17.9 (17.8–18.1)	1.8	18 (2)	14	29
Mother's weight in kg	931	51.8 (51.3–52.2)	6.4	51 (8.3)	35.1	79.1
Mother's height in cm	931	157.9 (157.5–158.4)	6.9	157.5 (9.2)	136	177.4
Body mass index	931	20.7 (20.6–20.9)	2.0	20.7 (2.4)	15	35.2
Mid-upper arm circumference	931	23.5 (23.4–23.6)	1.8	23.5 (1.8)	13.25	31.1
Haemoglobin level in g/dl	931	13.2 (13.1–13.3)	1.2	13.2 (1.4)	7.5	17.1
Total number of pregnancies	931	2.6 (2.5–2.7)	1.6	2 (3)	1	10
Dietary diversity score	931	4.5 (4.3–4.6)	1.9	4 (3)	1	8
Household food insecurity score	931	4 (3.8–4.2)	3.2	4 (5)	0	19
People living in the household	931	4.8 (4.7–4.9)	1.6	4 (2)	3	11
Age of the child in months	931	14.2 (13.8–14.6)	6.1	13.9 (10.2)	2.0	23.9

community based, while the other study was institutional. In addition, mothers in our study may be benefitting from the staple crop ensete, which is a good source of iron (Bosha et al., 2016; Mohammed et al., 2013). However, the prevalence of anaemia in our study was higher than that found in Wolayita zone, southern Ethiopia (11%) (Julla et al., 2018). That study also reported a mean haemoglobin level (13.5 g/dl), which was a little higher than ours (13.2 g/dl). In addition, the median haemoglobin level in our study (13.2 g/dl) was lower than the median reported in a previous study from the rural Sidama zone (the current Sidama region) (13.8 g/dl) (Gebreegziabher & Stoecker, 2017). However, the previous study had included all women in the reproductive age group. Thus, the haemoglobin levels reported in our study might show mothers' situation in terms of recent delivery and lactation (Roba et al., 2018). This finding indicates the need for promoting maternal health services utilisation and iron supplementation for pregnant mothers. While food fortification is a national-level food-based approach to prevent micronutrient deficiency diseases including anaemia (EPHI & ICF, 2019), access to, and utilisation of, fortified foods should be promoted.

Our study found a positive linear association between dietary diversity score and haemoglobin level of the mother. A similar positive association was reported by a study done in the eastern lowlands of Ethiopia (Roba et al., 2015). Moreover, dietary diversity was found to be associated with haemoglobin levels in studies done in other parts of Ethiopia (Alemayehu, 2017; Seifu & Yilma, 2020). In addition, low dietary diversity was found among more than half of the mothers (62.4%) in our study; this is in line with a study done in the Amhara region, northern Ethiopia, which reported 66% (Fentahun & Alemu, 2020). Our study also showed that 40% of the mothers had consumed fruits during the previous 24 h. This proportion is low, as the area is among the fruit-producing areas in Ethiopia (Biazin et al., 2018). However, most fruits are seasonal and mainly used for income-generation purposes (Adane et al., 2019).

In general, our findings showed that low dietary diversity among mothers is a persistent problem, calling for national actions in addition to local interventions. The local interventions can consider school farming, and fish and poultry farming, using the locally available resources. Intervention at the national level may include establishing rural food markets, to improve accessibility and affordability of nutritious foods at the local market. In addition, it will encourage people to be engaged in diverse agricultural activities (home gardening, fish and poultry farming), to generate income from the local market (Hirvonen & Headey, 2018). Furthermore, the use of a wild grain (amaranth) in this area, where low dietary diversity was a common problem, should be considered. A recent study from southern Ethiopia reported the potential of this important plant for improving haemoglobin levels among children (Orsango et al., 2020).

We did not find any previous study in Ethiopia that evaluated the association between weight and haemoglobin status of mothers. Our study showed that the weight of the mother was positively associated with haemoglobin level; this was in agreement with a study done among rural Indian adolescent girls (Ahankari et al., 2020).

In our study, secondary school attendance was also shown to be positively associated with the haemoglobin level of the mother. Again, a similar association was reported by a study done in the rural areas of Ethiopia (Roba et al., 2015). Another study from Arba Minch district, southern Ethiopia (Tikuye et al., 2019) also reported a similar association; however, that study included only those mothers who had given birth in the previous 6 months. This finding may indicate that education may influence one's nutritional status in different ways; for example, educated people can have better income to afford nutritious foods. Even though mothers in our study were not employed, educated mothers may have more information and better creativity to help improve their income. Hence, education can be one

TABLE 5 Regression coefficients (crude and adjusted) of independent variables with the outcome variables: haemoglobin level (g/dl) and body mass index (kg/m^2), in rural Dale district, Ethiopia, 2018

Variable	Haemoglobin level of the mother		Body mass index of the mother	
	Unadjusted coefficients (95% CI)	Adjusted coefficients (95% CI)	Unadjusted coefficients (95% CI)	Adjusted coefficients (95% CI)
Mother's age	−0.02 (−0.03 to −0.002)	0.002 (−0.02 to 0.02)	−0.003 (−0.03 to 0.02)	
Mother's age at first pregnancy	0.02 (−0.02 to 0.07)		−0.02 (−0.09 to 0.05)	
Weight in kg	0.03 (0.02–0.04)	0.02 (0.003–0.03)*		
Height in cm	0.03 (0.02–0.04)	0.01 (−0.001 to 0.03)		
Dietary diversity score	0.1 (0.04–0.14)	0.08 (0.03–0.12)**	0.14 (0.06–0.22)	0.08 (0.01–0.16)*
Household food insecurity score	−0.02 (−0.04 to 0.003)	−0.02 (−0.04 to 0.004)	−0.03 (−0.07 to 0.01)	−0.02 (−0.06 to 0.02)
Number of people living in the household	−0.08 (−0.12 to −0.03)	−0.05 (−0.14 to 0.04)	0.03 (−0.06 to 0.11)	
Total number of pregnancies	−0.08 (−0.13 to −0.04)	−0.003 (−0.11 to 0.1)	−0.01 (−0.1 to 0.08)	
Educational status				
no education	1	1	1	
primary school	0.28 (0.07–0.5)	0.15 (−0.08 to 0.37)	0.3 (−0.08 to 0.67)	0.16 (−0.22 to 0.53)
secondary school	0.51 (0.29–0.74)	0.34 (0.08–0.59)*	0.57 (0.18–0.97)	0.32 (−0.08 to 0.72)
Place of last delivery (923)				
home	1	1	1	
health institution	0.12 (−0.05 to 0.28)	0.02 (−0.14 to 0.18)	0.07(−0.21 to 0.36)	
Current use of family planning method (929)				
no	1	1	1	
yes	0.2 (− 0.1 to 0.5)	0.1 (−0.21 to 0.4)	0.66 (0.14–1.19)	0.57 (0.04–1.09)
Wealth index				
lower	1	1	1	
middle	0.03 (−0.15 to 0.22)	−0.04 (−0.22 to 0.14)	0.09 (−0.23 to 0.40)	0.04 (−0.28 to 0.35)
upper	0.13 (−0.06 to0.32)	−0.02 (−0.22 to 0.18)	0.77 (0.44–1.09)	0.60 (0.27–0.94)***

Note: Variables with $p \geq 0.25$ in the bivariable (unadjusted) regression were excluded from the multivariable (adjusted) regression.
*$p < 0.01$; **$p < 0.05$; ***$p < 0.001$.

of the factors which help to improve the nutritional status and the health of mothers.

The majority of mothers (85%) in our study were in the normal range of BMI (18.5 to 24.9 kg/m^2). The prevalence of underweight in our study (12.6%) was lower than in studies from northwest Ethiopia (25%) (Berihun et al., 2017) and the Afar region (33%) (Mulaw et al., 2021). The difference may be due to the regional differences documented by other studies, that showed that undernutrition among mothers of the reproductive age group in southern Ethiopia was less prevalent (Dagnew & Asresie, 2020; Sserwanja & Kawuki, 2020). The mean (SD) BMI in our study was 20.7 (2.0) kg/m^2; this was the same as the 2016 national EDHS report (20.7 kg/m^2) (Centeral Statstical Agency CSA & ICF, 2016). However, the prevalence of overweight in our study (2.5%) was lower than the EDHS report (8%). The difference can be explained by the different scope and setting: nationwide survey compared to a rural district study. Another study from northwest Ethiopia reported a prevalence of overweight (about 2%) that was very similar to our finding (Berihun et al., 2017).

In our study, the dietary diversity of the mother was positively associated with BMI, which was in line with a study from another district in southern Ethiopia (Boke et al., 2021). However, the other study was done in the town of the district, unlike ours. In addition, our findings showed that the household wealth index (the upper quartile) was positively associated with BMI. Similarly, the above-mentioned study from southern Ethiopia (Boke et al., 2021) reported a positive association between a household's upper wealth index and the BMI of mothers. This association may be due to the fact that wealthier people can have better access to more nutritious animal-source foods. However, this implies the need for the promotion of a healthy lifestyle among wealthier people, who are in a food transition, to prevent overweight, obesity, and associated non-communicable diseases (Hailemariam et al., 2020; Yeshaw et al., 2020).

In our study, the prevalence of household food insecurity was high (78.5%), though it was not associated with the haemoglobin level or BMI of the mother. The possible explanation for the lack of association may be that dietary diversity is a better indicator of haemoglobin level than household food insecurity, as demonstrated in this study. People may respond 'no' to most of the HFIAS questions if they think that they have enough ensete or maize only; they may not realise the risk of monotonous diets. It was also shown in this study that the majority of households reported that they had eaten a limited variety of food in the 4 weeks prior to this study. Hence, micronutrient deficiency diseases like anaemia are more related to food quality rather than quantity. The other possible reason may be that mothers have received iron supplementation during pregnancy, even though this was not fully assessed in the current study.

However, the Sidama region (the former Sidama zone) was one of the areas where the Productive Safety Net Programme (PSNP) has been working since 2005 (Galato, 2020); nevertheless, household food insecurity has remained a major problem (Dafursa & Gebremedhin, 2019). The possible explanation is that the programme is targeting highly vulnerable and drought-prone areas. The drought-prone areas in the Sidama region are Boricha and Loko Abaya, which are located in the Central Rift Valley region (Belayneh et al., 2020). Severely food-insecure households in a few *kebeles* of the Dale district are being supported by the programme. Although our study found that the majority of the households had mild to severe food insecurity, the programme was operating in only three of our study *kebeles*. We did not obtain data from individual households regarding this programme. Another possible explanation for the high food insecurity might be seasonality issues; our data was collected from August to November, known for relative food shortage. In addition, we did not analyse complications faced during pregnancy, delivery or after delivery, and are not able to tell whether these were associated with any of the nutritional problems among mothers.

4.1 | Strengths and weaknesses of the study

The strengths of this study included being a community-based study using a random sampling technique and the analytical approach using a multilevel mixed-effect model to account for clustering. Collecting comprehensive data, through interviews, measurements and rapid field tests, was an additional strength of our study. On the other hand, the limitations of our study included selection bias, recall bias and measurement bias. Selection bias was due to the replacement of some mothers who left their residence before enrolment and a potential recall bias was due to self-reported data such as age, past reproductive events and dietary recall. However, to minimise bias, we used strategies such as taking all measurements twice and formulating questions in different ways. Survivor bias may also exist, since our samples were mother-child pairs, and mothers who had lost their children were not included. In addition, the fact that we have no data from the local health facilities concerning women's health service coverage may create some bias.

5 | CONCLUSION

In our study, anaemia and underweight were less and moderately prevalent, respectively, among mothers who had a child less than 2 years of age, compared to the 2016 national EDHS report. However, the majority of the mothers had low dietary diversity. In addition, our findings showed that poor dietary diversity was a single factor positively associated with both low haemoglobin levels and low BMI. Household food insecurity was experienced by the majority of mothers, but did not predict the nutritional status of mothers in our study. However, it is obvious that access, availability and sustainability of nutritious foods were sparse. Education and promotion of minimum dietary diversity among mothers may help to improve their nutritional status. Strengthening the existing nutrition interventions like PSNP and planning new community-based nutrition interventions may help to improve access to nutritious food in rural households. Moreover, the missed opportunity of using the wild amaranth grain should be considered.

AUTHOR CONTRIBUTIONS

Tsigereda B. Kebede, Selamawit Mengesha, Bernt Lindtjorn and Ingunn Marie S. Engebretsen conceptualised the research idea, designed the study and wrote the protocol. Tsigereda B. Kebede and Ingunn Marie S. Engebretsen acquired and analysed the data and drafted the manuscript. Ingunn Marie S. Engebretsen, Bernt Lindtjorn and Selamawit Mengesha guided the study design, helped the data analysis and provided constructive comment in drafting the manuscript. All of the authors have read and approved the final manuscript.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICAL STATEMENT

Ethical approval was obtained from Hawassa University College of Medicine and Health Sciences Institutional review board, Ethiopia (reference number; IRB/025/10, Date: 21/12/2017) and from Norwegian Regional Ethical Committee (REK), Norway (reference number; 2018/90/REK Vest, Date: 07/03/2018). All the necessary official letters were obtained from the concerned bodies at regional and district levels. The respondent's signature or finger stamp was obtained before enrolment to signify their willingness to participate in our study. The data is kept in a secured place to maintain confidentiality. Furthermore, personal or household identifiers were not used to communicate our findings.

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REFERENCES

Abebaw, A., Gudayu, T. W., & Kelkay, B. (2020). Proportion of immediate postpartum anaemia and associated factors among postnatal mothers in northwest Ethiopia: A cross-sectional study. *Anemia*, *2020*, 8979740. https://doi.org/10.1155/2020/8979740

Adane, F., Legesse, A., Weldeamanuel, T., & Belay, T. (2019). The contribution of a fruit tree-based agroforestry system for household income to smallholder farmers in Dale District, Sidama Zone, Southern Ethiopia. *Advances in Plants & Agriculture Research*, *9*(1), 78–84.

Ahankari, A. S., Tata, L. J., & Fogarty, A. W. (2020). Weight, height, and midupper arm circumference are associated with haemoglobin levels in adolescent girls living in rural India: A cross-sectional study. *Maternal & child nutrition*, *16*(2), e12908. https://doi.org/10.1111/mcn.12908

Alemayehu, M. (2017). Factors associated with anemia among lactating mothers in subsistence farming households from selected districts of Jimma zone, south western Ethiopia: A community based cross-sectional study. *Journal of Nutrition and Food Sciences*, *7*(3), 595. https://doi.org/10.4172/2155-9600.1000595

Anshebo, D., Geda, B., Mecha, A., Liru, A., & Ahmed, R. (2020). Utilization of institutional delivery and associated factors among mothers in Hosanna Town, Hadiya Zone, Southern Ethiopia: A community-based cross-sectional study, *PloS One 15*, (12), e0243350. https://doi.org/10.1371/journal.pone.0243350

Areru, H. A., Dangisso, M. H., & Lindtjørn, B. (2021). Low and unequal use of outpatient health services in public primary health care facilities in southern Ethiopia: A facility-based cross-sectional study. *BMC Health Services Research*, *21*(1), 776. https://doi.org/10.1186/s12913-021-06846-x

Aychiluhm, S. B., Tadesse, A. W., Mare, K. U., Abdu, M., & Ketema, A. (2020). A multilevel analysis of short birth interval and its determinants among reproductive age women in developing regions of Ethiopia. *PLoS One*, *15*(8), e0237602. https://doi.org/10.1371/journal.pone.0237602

Azage, M., Motbainor, A., & Nigatu, D. (2020). Exploring geographical variations and inequalities in access to improved water and sanitation in Ethiopia: Mapping and spatial analysis. *Heliyon*, *6*(4), e03828. https://doi.org/10.1016/j.heliyon.2020.e03828

Belayneh, M., Loha, E., & Lindtjørn, B. (2020). 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. *Ecology of Food and Nutriton*, *60*(1), 4469. https://doi.org/10.1080/03670244.2020.1789865

Berihun, S., Kassa, G. M., & Teshome, M. (2017). Factors associated with underweight among lactating women in Womberma woreda, Northwest Ethiopia; A cross-sectional study. *BMC Nutrition*, *3*, 46. https://doi.org/10.1186/s40795-017-0165-z

Biazin, B., Haileslassie, A., Zewdie, T., Mekasha, Y., Gebremedhin, B., Fekadu, A., & Shewage, T. (2018). Smallholders' avocado production systems and tree productivity in the southern highlands of Ethiopia. *Agroforestry Systems*, *92*(1), 127–137.

Birhanu, T. T., & Tadesse, A. W. (2019). Food insecurity and mental distress among mothers in rural tigray and SNNP regions, Ethiopia. *Psychiatry Journal*, *2019*, 7458341. https://doi.org/10.1155/2019/7458341

Boke, M. M., Yesuf, A., & Gutema, B. T. (2021). Prevalence of undernutrition and associated factors among lactating mothers of Angecha District, Kembata Tembaro Zone, Southern Ethiopia. *Journal of Nutrition and Metabolics*, *2021*, 6691982. https://doi.org/10.1155/2021/6691982

Borde, M. T., Loha, E., Johansson, K. A., & Lindtjørn, B. (2020). Financial risk of seeking maternal and neonatal healthcare in southern Ethiopia: A cohort study of rural households. *International Journal for Equity in Health*, *19*(1), 69. https://doi.org/10.1186/s12939-020-01183-7

Bosha, A., Dalbato, A. L., Tana, T., Mohammed, W., Tesfaye, B., & Karlsson, L. M. (2016). Nutritional and chemical properties of fermented food of wild and cultivated genotypes of enset (*Ensete ventricosum*). *Food Research International*, *89*(Pt 1), 806–811. https://doi.org/10.1016/j.foodres.2016.10.016

Centeral Statstical Agency (CSA), & ICF. (2016). Ethiopia: demographic and health survey *2016*. CSA and ICF. https://dhsprogram.com/pubs/pdf/FR328/FR328.pdf

Christian, P., Mullany, L. C., Hurley, K. M., Katz, J., & Black, R. E. (2015). Nutrition and maternal, neonatal, and child health. *Seminars in Perinatology*, *39*(5), 361–372. https://doi.org/10.1053/j.semperi.2015.06.009

Coates, J., Swindale, A., & Bilinsky, P. (2007). *Household food insecurity access scale (HFIAS) for measurement of food access: Indicator guide (version 3)*. Food and Nutrition Technical Assisstance III. https://www.fantaproject.org/sites/default/files/resources/HFIASENG-v3-Aug-07.pdf

Dafursa, K., & Gebremedhin, S. (2019). Dietary diversity among children aged 6–23 months in Aleta Wondo District, Southern Ethiopia. *Journal of Nutrition and Metabolism*, *2019*, 2869424. https://doi.org/10.1155/2019/2869424

Dagnew, G. W., & Asresie, M. B. (2020). Factors associated with chronic energy malnutrition among reproductive-age women in Ethiopia: An analysis of the 2016 Ethiopia demographic and health survey data. *PLoS One*, *15*(12), e0243148. https://doi.org/10.1371/journal.pone.0243148

Dean, A. G., Sullivan, K. M., & Soe, M. M. (2013). *OpenEpi: Open Source Epidemiologic Statistics for Public Health*. www.OpenEpi.com

Ethiopian Public Health Institute (EPHI), & ICF. (2019). *Ethiopia Mini Demographic and Health Survey 2019:* Final report. EPHI and ICF. https://dhsprogram.com/pubs/pdf/FR363.pdf

Farah, A. M., Endris, B. S., & Gebreyesus, S. H. (2019). Maternal undernutrition as proxy indicators of their offspring's undernutrition: evidence from 2011 Ethiopia demographic and health survey. *BMC Nutrition*, *5*(1), 17. https://doi.org/10.1186/s40795-019-0281-z

Federal Democratic Republic of Ethiopia. (2018). *Food and nutrition policy*. https://www.nipn.ephi.gov.et/sites/default/files/2020-05/Food%20and%20Nutrition%20Policy.pdf

Félix-Beltrán, L., Macinko, J., & Kuhn, R. (2021). Maternal height and double-burden of malnutrition households in Mexico: Stunted children with overweight or obese mothers. *Public Health Nutrition*, *24*(1), 106–116. https://doi.org/10.1017/s136898002000292x

Fentahun, N., & Alemu, E. (2020). Nearly one in three lactating mothers is suffering from inadequate dietary diversity in Amhara Region, Northwest Ethiopia. *Journal of Nutrition Metabolism*, *2020*, 7429034. https://doi.org/10.1155/2020/7429034

Galato, Z. G. (2020). Impacts of productive safety net program on household asset building, food security and annual income in Sidama Zone, Southern Ethiopia. *International Journal of Current Research*, *12*(2), 10343–10350.

Gebreegziabher, T., & Stoecker, B. J. (2017). Iron deficiency was not the major cause of anemia in rural women of reproductive age in Sidama zone, southern Ethiopia: A cross-sectional study. *PLoS One*, *12*(9), e0184742. https://doi.org/10.1371/journal.pone.0184742

Gebreyesus, S. H., Lunde, T., Mariam, D. H., Woldehanna, T., & Lindtjørn, B. (2015). Is the adapted household food insecurity access scale (HFIAS) developed internationally to measure food insecurity valid in urban and rural households of Ethiopia? *BMC Nutrition*, *1*(1), 2.

Girum, T., & Wasie, A. (2017). Correlates of maternal mortality in developing countries: An ecological study in 82 countries. *Maternal Health, Neonatology and Perinatology*, *3*, 19. https://doi.org/10.1186/s40748-017-0059-8

Hailemariam, T. W., Ethiopia, S. S., Alamdo, A. G., & Hailu, H. E. (2020). Emerging nutritional problem of adult population: Overweight/obesity and associated factors in Addis Ababa city communities, Ethiopia—A community-based cross-sectional study. *Journal of Obesity*, *2020*, 6928452. https://doi.org/10.1155/2020/6928452

Hirvonen, K., & Headey, D. (2018). Can governments promote homestead gardening at scale? Evidence from Ethiopia. *Global Food Security*, *19*, 40–47.

Jaacks, L. M., Kavle, J., Perry, A., & Nyaku, A. (2017). Programming maternal and child overweight and obesity in the context of undernutrition: Current evidence and key considerations for low- and middle-income countries. *Public Health Nutrition*, *20*(7), 1286–1296. https://doi.org/10.1017/s1368980016003323

Juju, D. B., & Sekiyama, M. (2018). Food security of adolescents in selected khat- and coffee-growing areas in the Sidama Zone, Southern Ethiopia. *Nutrients*, *10*(8), 980. https://doi.org/10.3390/nu10080980

Julla, B. W., Haile, A., Ayana, G., Eshetu, S., Kuche, D., & Asefa, T. (2018). Chronic energy deficiency and associated factors among lactating mothers (15–49 years old) in Offa Woreda, Wolayita Zone, SNNPR, Ethiopia. *World Scientific Research*, *5*(1), 13–23.

Kaldenbach, S., Engebretsen, I. M., Haskins, L., Conolly, C., & Horwood, C. (2021). Infant feeding, growth monitoring and the double burden of malnutrition among children aged 6 months and their mothers in KwaZulu-Natal, South Africa. *Maternal & Child Nutrition*, *18*(1), e13288.

Kenea, A., Negash, E., Bacha, L., & Wakgari, N. (2018). Magnitude of anemia and associated factors among pregnant women attending antenatal care in public hospitals of Ilu Abba Bora Zone, South West Ethiopia: A cross-sectional study. *Anemia*, *2018*, 9201383. https://doi.org/10.1155/2018/9201383

Mamo, H., & Dagnaw, A. (2021). Prevalence of short interpregnancy interval and its associated factors among pregnant women in Debre Berhan town, Ethiopia. *PLoS One*, *16*(8), e0255613. https://doi.org/10.1371/journal.pone.0255613

Mohammed, B., Gabel, M., & Karlsson, L. M. (2013). Nutritive values of the drought-tolerant food and fodder crop enset. *African Journal of Agricultural Research*, *8*(20), 2326–2333.

Mulaw, G. F., Mare, K. U., & Anbesu, E. W. (2021). Nearly one-third of lactating mothers are suffering from undernutrition in pastoral community, Afar region, Ethiopia: Community-based cross-sectional study. *PLoS One*, *16*(7), e0254075. https://doi.org/10.1371/journal.pone.0254075

Orsango, A. Z., Loha, E., Lindtjørn, B., & Engebretsen, I. M. S. (2020). Efficacy of processed amaranth-containing bread compared to maize bread on hemoglobin, anemia and iron deficiency anemia prevalence among two-to-five year-old anemic children in Southern Ethiopia: A cluster randomized controlled trial. *PLoS One*, *15*(9), e0239192. https://doi.org/10.1371/journal.pone.0239192

Patel, A., Prakash, A. A., Das, P. K., Gupta, S., Pusdekar, Y. V., & Hibberd, P. L. (2018). Maternal anemia and underweight as determinants of pregnancy outcomes: Cohort study in eastern rural Maharashtra, India. *BMJ Open*, *8*(8), e021623. https://doi.org/10.1136/bmjopen-2018-021623

Roba, K. T., O'Connor, T. P., Belachew, T., & O'Brien, N. M. (2015). Seasonal variation in nutritional status and anemia among lactating mothers in two agro-ecological zones of rural Ethiopia: A longitudinal study. *Nutrition*, *31*(10), 1213–1218.

Roba, K. T., O'Connor, T. P., Belachew, T., & O'Brien, N. M. (2018). Concurrent iron and zinc deficiencies in lactating mothers and their children 6–23 months of age in two agro-ecological zones of rural Ethiopia. *European Journal of Nutrition*, *57*(2), 655–667. https://doi.org/10.1007/s00394-016-1351-5

Seifu, B., & Yilma, D. (2020). Prevalence and associated factors of anemia among lactating women in Ethiopia from 2010 to 2020: A systematic review and meta-analysis. *Biomedical Research*, *5*(2), 327–342.

Sserwanja, Q., & Kawuki, J. (2020). Prevalence of underweight and associated factors among lactating women in Ethiopia: A mini-review. *Journal of Advances in Medicine and Medical Research*, *32*(8), 57420.

Sullivan, K. M., Mei, Z., Grummer-Strawn, L., & Parvanta, I. (2008). Haemoglobin adjustments to define anaemia. *Tropical Medicine & International Health*, *13*(10), 1267–1271.

Swindale, A., & Bilinsky, P. (2006). Development of a universally applicable household food insecurity measurement tool: Process, current status, and outstanding issues. *The Journal of Nutrition*, *136*(5), 1449S–1452S.

Tikuye, H. H., Gebremedhin, S., Mesfin, A., & Whiting, S. (2019). Prevalence and factors associated with undernutrition among exclusively breastfeeding women in Arba Minch Zuria District, Southern Ethiopia: A cross-sectional community-based study. *Ethiopian Journal of Health Sciences*, *29*(1), 913–922. https://doi.org/10.4314/ejhs.v29i1.13

Were, J. M., Stranges, S., & Creed, I. F. (2020). Fertility is a key predictor of the double burden of malnutrition among women of child-bearing age in sub-Saharan Africa. *Journal of Global Health*, *10*(2), 020423. https://doi.org/10.7189/jogh.10.020423

World Health Organisation (WHO). (2011). Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Vitamin and Mineral Nutrition Information System. World Health Organisation/NMH/NHD/MNM/11.1. https://who.int/entity/vmnis/indicators/haemoglobin

World Health Organisation (WHO). (2019). *Nutrition landscape information system (NLIS) country profile indicators: Interpretation guide*. World Health Organisation. https://www.who.int/publications/i/item/9789241516952

Yeshaw, Y., Kebede, S. A., Liyew, A. M., Tesema, G. A., Agegnehu, C. D., Teshale, A. B., & Alem, A. Z. (2020). Determinants of overweight/obesity among reproductive age group women in Ethiopia: Multilevel analysis of Ethiopian demographic and health survey. *BMJ Open*, *10*(3), e034963.

Zewdie, S., & Fage, S. G. (2021). Undernutrition among pregnant women in rural communities in Southern Ethiopia. *International Journal of Wonen's Health*, *13*, 73–79. https://doi.org/10.2147/ijwh.s285132

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Kebede, T. B., Mengesha, S., Lindtjorn, B., & Engebretsen, I. M. S. (2022). Anaemia, anthropometric undernutrition and associated factors among mothers with children younger than 2 years of age in the rural Dale district, southern Ethiopia: A community-based study. *Maternal & Child Nutrition*, e13423. https://doi.org/10.1111/mcn.13423

Paper II supplementary Table

Table S1: Frequency of occurrence of the nine household food insecurity conditions in the rural Dale district of Ethiopia, 2018 (N=931).

Conditions of household food insecurity	**Frequency of occurrence over the four weeks**			
	Not happened N (%)	1 – 2 times N (%)	3 – 10 times N (%)	>10 times N (%)
Worried about getting enough food	408 (43.8)	352 (37.8)	160 (17.2)	11 (1.2)
Unable to eat preferred foods	408 (43.8)	327 (35.1)	189 (20.3)	7(0.8)
Ate a limited variety of foods	362 (38.9)	326 (35)	176 (18.9)	67 (7.2)
Ate foods they really didn't want to eat	731 (78.5)	149 (16)	47 (5)	4 (0.4)
Ate a smaller meal	587 (63.1)	214 (23)	126 (13.5)	4 (0.4)
Ate fewer meals in a day	659 (70.8)	189 (20.3)	80 (8.6)	3 (0.3)
No food of any kind in the household	834 (89.6)	65 (7)	31 (3.3)	1 (0.1)
Went to sleep at night hungry	831 (89.3)	81 (8.7)	19 (2.0)	0
Went a whole day and night without eating	886 (95.2)	38 (4.1)	6 (0.6)	1 (0.1)

Paper II supplementary Table

Table S2: Correlation between the dependent variables: haemoglobin level, body mass index and mid-upper arm circumference (N=931)

	Haemoglobin level	Body mass index
Haemoglobin level		
Body mass index	0.085**	
MUAC	0.121**	0.549**

**Correlations had a P value < 0.01

Data collection tool for paper I-III

Questionnaire

Date of interview _____/_____/__________ (DD/MM/YYYY)

Keble ___________________ Sub-kebele __________________ Household code/ID ____________

SECTION ONE: Household related questions

Respondent: the Father, Mother, or other member of the household over the age of 18 years

1. Presence/absence of parents on the time of interview (tick in front of the response or write the answer on the space provided)

   1.1. Father is alive? yes____; No____

   1.2. Mother is alive? yes____; No____

2. Description of the respondent:

   1.1. Who is the respondent?

   a. Mother ______ b. Father ______ c. Other (specify) ________________

   1.2. Age of respondent ________ (write in completed years)

   1.3. Sex of the respondent; a. Male ____ b. Female____

3. How many people are currently living in this household? _______ (write in number)

   1.1. How many of them are children less than five years old? _______ (write in number)

   i. How many of them are female? _______ (write in number)

   ii. How many of them are male? _______ (write in number)

4. How the household is headed? (Choose one or write if you chose other)

   4.1. Headed by the father only ____ 4.3. Headed by both ____

   4.2. Headed by the mother only ____ 4.4. Other (specify) _________________

5. How many functional rooms does your household have? _________ (write in number)

   5.1. Is there a separate room for cooking? Yes _____ No _____

   5.2. Is there a separate room for animals? Yes _____ No _____ Not applicable _____

6. What is the material of the roof? (majority of the wall)

   6.1. Tatched Grass _____

   6.2. Iron sheets_____

   6.3. Other(mention) ____________

7. What is the material of the walls? (majority of the wall)

   7.1. Mud ______ 7.3. Bricks _____

   7.2. Cement _____ 7.4. Other (specify)_______________

8. What is the material of the floor? (majority of the floor)

8.1. Earth and dung ______
8.2.Plastered earth _____
8.3.Wood _____
8.4.Cement _____

9. What type of fuel does your household mainly use for cooking?

9.1. Electricity _____
9.2.Kerosene _____
9.3.Charcoal _____
9.4.Wood _____
9.5.Dried cow dung _____
9.6.Other (specify) _______________

10. What is the main source of water for your household?

10.1. Piped water ____
10.2. Protected well/spring _____
10.3. Unprotected well/spring _____
10.4. Other (specify) _____________________

11. Do you have any of the following operational items in your household?

11.1. Radio; yes _____, No _____
11.2. TV; yes _____, No _____
11.3. Mobile phone/fixed phone; yes _____, No _____
11.4. Bike; yes _____, No _____
11.5. Motor cycle; yes _____, No _____
11.6. Car; yes _____, No _____

12. Do you have any of the following animals?

12.1. Hens; yes _____, No _____
12.2. Goat; yes _____, No _____
12.3. Sheep; yes _____, No _____
12.4. Cows; yes _____, No _____
12.5. Bulls/Ox; yes _____, No _____
12.6. Donkey; yes _____, No _____
12.7. Horse; yes _____, No _____

SECTION TWO: Questions about the reproductive characteristics and general information of the mother

Respondent should be the mother!

1. Age of the mother; ________ (write in years)
2. Marital status of the mother

   2.1. Unmarried ____ 2.3. Divorced ____

   2.2. Married ____ 2.4. Widowed ____
3. What is highest educational level of the mother?

   a. No schooling at all ______ c. Certificate/ diploma level _____

   b. Grade ______(write completed grade) d. Degree and above______
4. Is the mother employed? Yes_______, No ________ , (skip if not alive)
5. What is the total number of pregnancies _______, (write in numbers)
6. Total number of children alive; _______ (write in numbers)

   6.1. How many of them are girls; _____

   6.2. How many of them are boys;_____
7. Has the mother experienced any child loss? Yes _______, No _______
8. Age of the mother at her first pregnancy? _______ (write in years)
9. Currently pregnant? Yes _____, No _______ (if 'No', skip to question number 11)
10. If 'Yes' for question number 11, are you started ANC visit? Yes _____, No ______
11. If 'No' for question number 10, are you using any family planning method? Yes _____, No ______
12. Have you ever faced any complication during pregnancy or delivery? Yes _____, No ______
13. If yes, which complication, (**multiple choice is possible**)

    13.1. Abortion ____ 13.4. Infection ____

    13.2. Still birth ____ 13.5. High blood pressure _____

    13.3. Bleeding ____ 13.6. Other (specify) _______________

213. Have you faced any sickness in the past two weeks? Yes _____, No ______

214. If yes, what was your sickness? (Specify) ________________________________

SECTION THREE: Questions about the child participating in this study

Respondent: mother, father or other immediate legal care giver of the child!

1. Sex of the child; Male ____, Female_____
2. Vaccination card present? Yes ____, No ____
3. Age of the child; _____year and_____ months (write in completed year and completed months)
4. Date of birth, _____/_____/_________ (DD/MM/YYYY)
5. Date of birth is confirmed with vaccination card, birth certificate or health any health record;

   Yes ____ No ____
6. Birth order of the child; _______ (write in number)
7. Place of birth;
   - 7.1. Home _____
   - 7.2. Health institution _____
   - 7.3. On the way to health institution _____
   - 7.4. Other place (specify)______________
8. If your answer is 'Health institution, for the above question, write the name of the health institution;

   ____
9. Mode of delivery;
   - 9.1. Spontaneous Vaginal Delivery (SVD) ____
   - 9.2. Assisted vaginal delivery (AVD) ____
   - 9.3. Caesarian section (CS) ____
10. Birth weight; ___________ kg at birth
11. Is the birth weight confirmed with vaccination card or birth certificate, yes ____, No ____
12. Is your child currently on breastfeeding? Yes ____, No ____ (if Yes, go to question 15)
13. If 'No', age of child when stopping (months); ________
14. If 'No', what was the reason?
    - 14.1. Mother's health related _____
    - 14.2. Mother's job related_____
    - 14.3. Child health related_____
    - 14.4. Child satisfied with breast milk _____
    - 14.5. Separated from mother ____
    - 14.6. New pregnancy occurred ____
    - 14.7. Other (specify)_________________
15. When did you start, breast feeding to this child
    - 15.1. Immediately (within one hour after birth) _____
    - 15.2. After one hour, but before 24 hours from birth _____
    - 15.3. After 24-hour from birth _____

16. Did you give any feeds other than breast milk to the child before he/she got breastfed?

16.1. Yes _____ 16.2. No _____

17. If yes, what was given? (You can tick more than one choice)

17.1. Formula milk ______ 17.3. Sugar and water______

17.2. Cow's milk ______ 17.4. Other(specify) _________________

18. Is your child started complementary food?

18.1. Yes _______ 18.2. No _____

19. If yes, at what age the child started complementary food? _______months,

20. Was the child sick in the past two weeks? Yes _____, No ______

21. If yes, what was the illness? (Multiple answers is possible)

21.1. Diarrhea ____

21.2. Fever ____

21.3. Cough ____

21.4. Malaria ____

21.5. Other (specify) ____________

22. Has the child ever been hospitalized? Yes ______, No _____

22.1. If yes, write the reason for hospitalization (Reason ___________________________________)

23. Has the child ever been given nutritional support from a health worker? Yes ______, No ______

23.1. If yes write the nutritional support? (______________________________________)

SECTION FOUR: Dietary practice of the household

Respondent: the mother, father or any member over 18 years old!

1. What is the most common food of the family?
   - 1.1. Enset ____
   - 1.2. Maize ____
   - 1.3. Roots and tubers ____
   - 1.4. Teff ____
   - 1.5. Amaranth ____
   - 1.6. Other (Specify) ________________
2. How many meals per day the family is served? __________ (write in Number)
3. Is there any food which is forbidden in your family? Yes _____, No _____
4. If yes, write the food item and the reason for which it is forbidden?
   - 4.1. ______________ because ______________________________________
   - 4.2. ______________ because ______________________________________
5. Is there any food which is forbidden for young children? Yes _____, No _____
6. If yes, write the food item and the reason for which it is forbidden?
   - 6.1. ______________ because ____
   - 6.2. _______________ because ____
7. Is there any food which is forbidden for mothers during pregnancy/lactation? Yes _____, No _____
8. If yes, write the food item and the reason for which it is forbidden?
   - 8.2. ______________ because ____
   - 8.3. ______________ because ____

SECTION FIVE: Food access of the household (Household Food Security and Access Scale)

(Tick in front of the response of the respondent)

1.	In the past four weeks, did you worry that your household would not have	Yes ____ No ____	If 'No', go to

	enough food?		Q. 3
2.	How often this happen?	1. Rarely ____(once or twice in the past four weeks) 2. Sometimes____ (three to ten times in the past four weeks) 3. Often ____ (more than ten times in the past four weeks)	
3.	In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?	Yes ____ No ____	If 'No', go to Q. 5
4.	How often this happen?	1. Rarely ___(once or twice in the past four weeks) 2. Sometimes___ (three to ten times in the past four weeks) 3. Often ___ (more than ten times in the past four weeks)	
5.	In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?	Yes _____ No _____	If 'No', go to Q. 7
6.	How often this happen?	1. Rarely ___ (once or twice in the past four weeks) 2. Sometimes___ (three to ten times in the past four weeks) 3. Often ___ (more than ten times in the past four weeks)	
7.	In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources	Yes _____ No _____	If 'No', go to Q. 9
8.	How often this happen?	1. Rarely ____(once or twice in the past four weeks) 2. Sometimes___(three to ten times in the past four weeks) 3. Often ___ (more than ten times in the past four weeks)	
9.	In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	Yes _____ No _____	If 'No', go to Q. 11
10.	How often this happen?	1. Rarely ___(once or twice in the past four weeks) 2. Sometimes___ (three to ten times in the past four weeks) 3. Often ___ (more than ten times in the past four weeks)	
11.	In the past four weeks, did you or any other household member have to eat fewer meals in a day because there was not enough food?	Yes _____ No _____	If 'No', go to Q.13
12.	How often this happen?	1. Rarely ____ (once or twice in the past four weeks) 2. Sometimes____ (three to ten times in the past four weeks) 3. Often ____ (more than ten times in the past four weeks)	
13.	In the past four weeks, was there ever	Yes _____	If 'No',

	no food to eat of any kind in your household because of lack of resources to get food?	No _____	go to Q. 15
14.	How often this happen?	1. Rarely _____(once or twice in the past four weeks) 2. Sometimes_____ (three to ten times in the past four weeks) 3. Often _____ (more than ten times in the past four weeks)	
15.	In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?	Yes _____ No _____	If 'No', go to Q. 17
16.	How often this happen?	1. Rarely _____(once or twice in the past four weeks) 2. Sometimes_____ (three to ten times in the past four weeks) 3. Often _____ (more than ten times in the past four weeks)	
17.	In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?	Yes _____ No _____	If 'No', go to Q. 19
18.	How often this happen?	1. Rarely _____(once or twice in the past four weeks) 2. Sometimes_____ (three to ten times in the past four weeks) 3. Often _____ (more than ten times in the past four weeks)	
19.	Was yesterday a celebration or feast day where you ate special foods or where you ate more, or less than usual	Yes _____ No _____	If 'No', go to Q. 21
20.	How often this happen?	1. Rarely ___(once or twice in the past four weeks) 2. Sometimes___(three to ten times in the past four weeks) 3. Often ____ (more than ten times in the past four weeks)	
21.	Could you please specify the primary source for obtaining food	1. Own production ______ 2. Purchasing ______ 3. Exchanged for labour ______ 4. Food aid/support ______ 5. Other(specify) ____________________	

SECTION SIX: Dietary diversity and Food Frequency for the index child

Respondent can be mother, father or immediate legal care giver of the child

Read each item carefully to the respondent, repeat if necessary and record the response before going to the next item			
		Since the child woke up yesterday morning till the	Tick in the category that best describes the frequency with which this child usually eats the particular food item

Q.N	Food type	child woke up this morning, did the child eat any of the following food type?	Always	Often	Sometimes	Rarely	Never
1.	Bread, injera, porridge, or other foods made from Maize, bread, sorghum, teff, wheat, barley, rice, and the like,	Yes ______ No ______					
2.	Commercial fortified infant or baby food (e.g. Cerelac, Fafa noodles/indomi?)	Yes ______ No ______					
3.	Pumpkin, carrots, squash, or sweet potatoes that are yellow or orange inside?	Yes ______ No ______					
4.	White potatoes, sweet potato, kocho/bulla, white yams, cassava, or other foods made from roots/tubers?	Yes ______ No ______					
5.	Any dark green leafy vegetables (e.g. kale)	Yes ______ No ______					
6.	Any other vegetables? (e.g. Moringa,)	Yes ______ No ______					
7.	Mangoes, papayas, or other orange colored fruits?	Yes ______ No ______					
8.	Any other fruits?	Yes ______ No ______					
9.	Liver, kidney, heart, or other organ meat?	Yes ______ No ______					
10.	Any meat, such as beef, pork, lamb, goat, chicken?	Yes ______ No ______					

11.	Eggs?	Yes ______ No ______					
12.	Fish?	Yes ______ No ______					
13.	Any foods made from beans, peas, lentils, or nuts?	Yes ______ No ______					
14.	Cheese, milk, yoghurt or other food made from milk?	Yes ______ No ______					
15.	Fats or oils (e.g., vegetable oil, ghee, shenokibe) or foods made with them?	Yes ______ No ______					
16.	Sugar and other sugary products (e.g. chocolates, biscuit, sweets, candies)	Yes ______ No ______					
17.	Sugar and other sugary products (e.g. chocolates, biscuit, sweets, candies, soda)	Yes ______ No ______					
18.	Any other food that I have not mentioned?		Specify____ __________				
19.	How many times did this child eat solid or soft/mashed foods yesterday during the day or night?		_____________meals (write the number of meals per day) 88. I don't know ________				

SECTION SEVEN: Dietary Diversity and Food Frequency for the mother

Respondent should be mother!

Read each item carefully to the respondent, repeat if necessary and record the response before going to the next item							
Q.N	Food type	Since you woke up yesterday morning till you woke up this morning, did you eat any of the mentioned food type?	Tick in the category that best describes the frequency with which you usually eat the particular food item				
			Always	Often	Sometimes	Rarely	Never

1.	Bread, injera, porridge, or foods made from cereals like;Maize, bread, sorghum, teff, wheat, barley, rice,	Yes ______ No ______						
2.	Commercial fortified food (e.g. noodles/indomi?)	Yes ______ No ______						
3.	Pumpkin, carrots, squash, or sweet potatoes that are yellow or orange inside	Yes ______ No ______						
4.	White potatoes, sweet potato, kocho/bulla, white yams, cassava, or foods made from roots/tubers?	Yes ______ No ______						
5.	Any dark green leafy vegetables (e.g. kale)	Yes ______ No ______						
6.	Any other vegetables? (e.g. Moringa,)	Yes ______ No ______						
7.	Mangoes, papayas, or other orange colored fruits?	Yes ______ No ______						
8.	Any other fruits?	Yes ______ No ______						
9.	Liver, kidney, heart, or other organ meat?	Yes ______ No ______						
10.	Any meat, such as beef, pork, lamb, goat, chicken?	Yes ______ No ______						
11.	Eggs?	Yes ______ No ______						
12.	Fish?	Yes ______ No ______						
13.	Any foods made from beans, peas, lentils, nuts?	Yes ______ No ______						
14.	Cheese, milk, yoghurt or other food made from milk?	Yes ______ No ______						
15.	Other fats or oils (e.g.,	Yes ______						

	vegetable oil, ghee, shenokibe) or foods made with them?	No ______					
16.	Sugar and other sugary products (e.g. chocolates, biscuit, sweets, candies, soda)	Yes ______ No ______					
17.	Sugar and other sugary products (e.g. chocolates, biscuit, sweets, candies, soda)	Yes ______ No ______					
18.	Any other foods that I have not mentioned?		Yes _____(specify) ________________________________ No ______				

SECTION EIGHT: Measure and record the result of anthropometric measurements for the mother and the child

		First measurement	Second measurement	Average	Remark
1.	Weight of the mother				
2.	Height of the mother				
3.	MUAC of the mother				
4.	Hemoglobin level of the mother (in g/dl)	______________________ g/dl			
		First measurement	Second measurement	Average	Remark
1.	Weight of the child				
2.	Length of the child				
3.	MUAC of the child				
4.	Haemoglobin level of the child (in g/dl)	______________________ g/dl			

Ethical approvals

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HAWASSA UNIVERSITY
COLLEGE OF MEDICINE AND HEALTH SCIENCES
Institutional Review Board

Ref. No: IRB/025/10

Date: 21/12/2017

Name of Researcher(s): ***Tsigereda Behailu, Ingunn Marie S. Engebretsen, Selamawit Mengesha, Bernt Lindtjorn***

Topic of Proposal: ***Dietary diversity and household food insecurity and their association with the nutritional status of women and young children in rural kebeles of Dale Woreda, southern Ethiopia***

Dear researcher(s),

The Institutional Review Board (IRB) at the College of Medicine and Health Sciences of Hawassa University has reviewed the aforementioned research protocol with special emphasis on the following points:

1. Are all principles considered?
   - 1.1. Respect for persons: Yes ☑ No ☐
   - 1.2. Beneficence: Yes ☑ No ☐
   - 1.3. Justice: Yes ☑ No ☐
2. Are the objectives of the study ethically achievable? Yes ☑ No ☐
3. Are the proposed research methods ethically sound? Yes ☑ No ☐

Based on the aforementioned ethical assessment, the IRB has:

A. Approved the proposal for implementation ☑
B. Conditionally Approved ☐
C. Not Approved ☐

Yours faithfully,

Ayalew Astatkie (PhD),
Institutional Review Board Chairperson.

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REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK sør-øst	Hege Cathrine Finholt, PhD	22857547	08.03.2018	2018/90/REK sør-øst D
			Deres dato:	Deres referanse:
			07.03.2018	

Vår referanse må oppgis ved alle henvendelser

Ingunn Marie Stadskleiv Engebretsen
University of Bergen

2018/90 Matvariasjon og matsikkerhet i relasjon til ernæringsstatus hos kvinner og barn i rurale Dale Woreda, sør Etiopia

Forskningsansvarlig: University of Bergen
Prosjektleder: Ingunn Marie Stadskleiv Engebretsen

Vi viser til søknad om forhåndsgodkjenning av ovennevnte forskningsprosjekt, samt til informasjonsskriv ettersendt 02.02.2018. Søknaden ble behandlet av Regional komité for medisinsk og helsefaglig forskningsetikk (REK sør-øst D) i møtet 14.02.2018. Vurderingen er gjort med hjemmel i helseforskningsloven (hfl.) § 10.

Prosjektleders prosjektbeskrivelse
The aim of the study is to describe the dietary practice and household food insecurity level and to determine its association with to the nutritional status of young children aged 0-24 months and women in the reproductive age group in Dale woreda. A community based household survey will be conducted in seven rural kebeles of Dale woreda, Southern Ethiopia from February 2018 to May 2018. Households will be picked using a systematic random sampling technique after proportional allocation to the size of household in each kebele. 985 mother-child pairs will be included in the study. Standard data collection tools will be adopted and modified based on the setting in Dale woreda. Data will be collected by face to face interview from the household and from mothers and caregivers of the child. Anthropometric measurements and haemoglobin level determination will be used in addition.

Vurdering
The Committee has no objections to implementation of the Research Project. The Committee does, however, have one comment to the letter of information:

The Health Research Act of 2008, paragraph 17, requires that all the legal guardians of the participating child must sign the consent form. Because of this, the letter of information must make space for the signatures of all the legal guardians of the participating child. Please submit the revised letter of information to REK.

Vedtak
The project is approved on the condition that it is conducted as described on the Application Form, and in the Research Protocol, and on the condition that the letter of information will be updated in accordance with the above-mentioned comment.

The approval is valid until 31.12.2018. For documentation and follow-up purposes, the data will need to be kept until 31.12.2023. The data must be stored as de-identified data, i.e. a file with key identifiable information stored separately from the file containing other data. The data must, be either deleted or anonymised within 6 months after this date.

Appeals process
The decision of the Committee may be appealed to the National Committee for Research Ethics in Norway. The appeal must be submitted to the Regional Committee for Research Ethics, Section B, South East Norway, The deadline for appeal is three weeks from the date on which you receive this letter.>

Med vennlig hilsen

Finn Wisløff
Professor em. dr. med.
Leder

Hege Cathrine Finholt, PhD
Rådgiver

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