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Nawiri Desk Study:

Drivers of child malnutrition in the Kenya arid and semi-arid lands

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Contents

Acronyms

ASAL	Arid and semi-arid lands
BMI	Body mass index
cm	Centimeter
DHS	Demographic and Health Survey
FAO	Food and Agriculture Organization of the United Nations
GAM	Global acute malnutrition
HAZ	Height-for-age z-score
IPC	Integrated Phase Classification
MAM	Moderate acute malnutrition
MUAC	Mid-upper arm circumference
WAZ	Weight-for-age z-score
WHZ	Weight-for-height z-score

Executive Summary

This desk study provides an overview of the existing evidence base and evidence gaps around the immediate and underlying drivers of child malnutrition, focusing on Marsabit and Isiolo County, but also drawing on studies conducted in neighboring arid and semi-arid lands (ASAL) counties in Kenya with similar climatic conditions. While this desk study only focuses on the immediate and underlying drivers, it is part of a larger review under the Nutrition in the ASALs within Integrated Resilient Institutions (Nawiri) program that includes additional desk studies that aim to capture the role of the basic drivers. Only peer-reviewed studies that included a measure of child malnutrition, either self-reported or anthropometrically defined (i.e., wasting, weight-for-height z-score (WHZ), height-for-age z-score (HAZ), mid-upper arm circumference (MUAC), etc.) across the ASAL counties in Kenya were included in the scoping review. Below we summarize the key findings in the literature and how they can better inform the Nawiri program.

Poor child malnutrition is a serious problem in the Kenyan ASALs, with most of the literature highlighting high levels of undernutrition, irrespective of year of data collection, county of data collection, and identified livelihood specialization, sex, age group, or nutrition indicator used. In addition, some of the literature highlights the growing problem of adult obesity in the ASALS as a consequence of chronic child undernutrition and the increased presence of the double burden of malnutrition (under- and overweight) at the household level. The consistency of low z-scores and high prevalence rates cannot be ignored and requires a renewed focus and shift in programmatic and policy approaches.

The relationship between dietary intake and/or food insecurity and child malnutrition is inconsistent, and part of a larger narrative around sedentarization in the ASALs. While the majority of studies specifically hypothesized and tested the relationship between dietary intake and malnutrition, not a single quantitative study found a significant link between consumption and wasting. The relationship between dietary intake and/or food insecurity and stunting/HAZ and underweight/weight-for-age z-score (WAZ) was more consistent, with a few studies showing a significant association. Both studies using participatory methods to identify drivers of acute malnutrition highlighted low milk consumption as a driver of child malnutrition. All studies looking at child consumption specifically focused on milk consumption as part of a general narrative that milk is critical for child growth, and that long-term patterns in the sedentarization of former pastoralist communities has led to the presence of fewer animals and hence less access to milk. However, attempts to look at the role of sedentarization on nutrition had mixed results. One study identified lower underweight and stunting prevalence when comparing pastoral vs. settled communities, another study found no differences across nutritional outcomes, and a third study found that children under 5 were taller in nomadic communities, but children between the age of 5 and 10 years were taller and heavier in the sedentary groups.

Indicators and proxies of child morbidity were consistently, with only one exception, associated with worse nutritional outcomes. However, directionality of those relationships continues to be an issue. Several studies found a link between infection or biomarkers of infection and wasting and or WHZ. Only one study reported no relationship between mucosal immune function and WAZ and WHZ, but did find a relationship with HAZ. Three studies using participatory or self-reported methods identified disease as a risk factor for malnutrition.

The social and care environment was identified as a risk factor for child malnutrition, but was only explored in studies using qualitative methods. Specifically, these studies identified the increasing workload of women and its impact on available time to care for young children as a major causal factor of worse nutrition outcomes.

An unhealthy environment and poor access to health services were consistently associated with poor nutrition outcomes, irrespective of the nutrition indicator used or the methodology applied. Specifically, studies identified access to clean drinking water and to improved toilet facilities as associated with better nutrition outcomes. Access to health services was noted to be associated with better nutrition outcomes also, but stigma related to taking malnourished children to the health center was a critical factor.

Wealth was consistently assumed, but inconsistently associated with child nutrition outcomes. Multiple studies made either direct assumptions around wealth, including the interpretation of non-wealth variables as proxies for wealth, or specifically included multiple measures of wealth in their analysis while ignoring other drivers. However, the actual evidence base is inconclusive, with several studies finding no relationship between nutrition outcomes and wealth. On the other hand, a handful of studies found a significant relationship between the poverty index and MUAC, economic status and wasting, stunting and wealth, and self-reported child malnutrition and wealth. One study, looking at data over 16 years, found that the role of wealth has diminished over time in relation to stunting.

Education of the household head, particularly of the female caretaker, was associated with better nutrition outcomes across multiple studies.

Sex and age matter a lot when it comes to nutrition outcomes. Multiple studies identified boys as having worse nutritional outcomes. However, the two studies that found no aggregate difference in nutrition outcomes by sex both had multiple within-year observations, indicating that sex differences might vary depending on the season of data collection. Nutrition outcomes also differed by age group, with the exception of wasting, contradicting existing literature that identifies children under 24 months as more vulnerable.

While the evidence base reviewed for this desk study on drivers of malnutrition is fairly slim, it does offer a treasure trove of information to better inform and design Nawiri program primary research. The review confirms that acute malnutrition is a problem in the Kenya ASALs, and that most of the drivers are under-studied, and yet several specific assumptions permeate the literature and program recommendations. Primary research under Nawiri will be designed to address some of the gaps in the evidence base, test existing assumptions, and identify programmatic recommendations to address acute malnutrition in Isiolo and Marsabit Counties.

Introduction

In this section, we present the overall goals of the Nawiri program and how this desk study relates both to Nawiri and the other desk studies conducted. Next, we present the conceptual framework for drivers of malnutrition, which guides both the focus of this desk study as well as how it is organized. Finally, we present information on how we conducted this desk study and the layout for the report.

Nawiri program: objective and goal, role of desk study within this

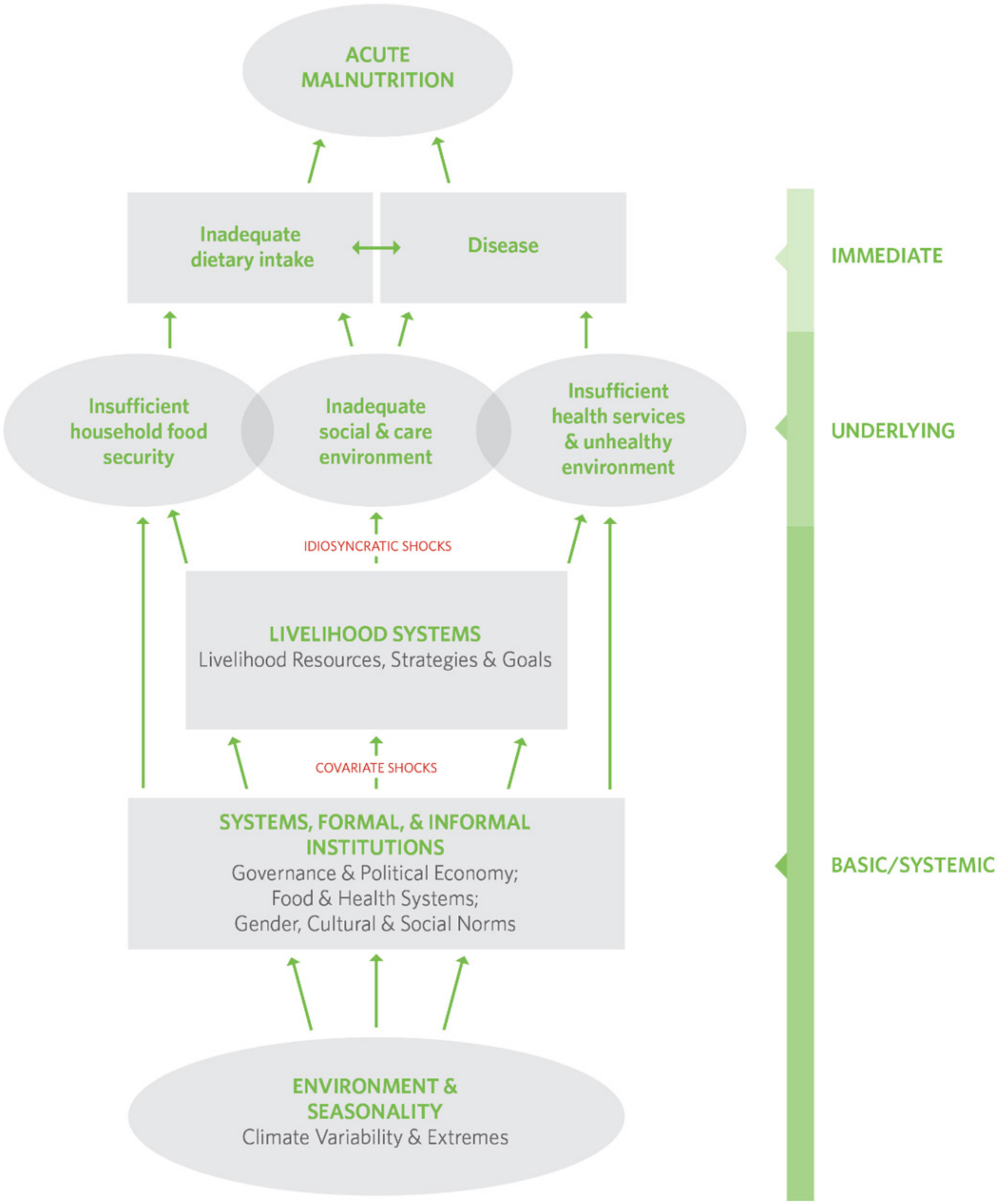
The desk study on "Drivers of child malnutrition in the Kenya arid and semi-arid lands (ASALs)" is part of the Nutrition in the ASALs within Integrated Resilient Institutions (Nawiri) program funded by USAID/Bureau of Humanitarian Assistance (BHA) and implemented by a consortium led by Catholic Relief Services (CRS). The Nawiri program is being implemented in Isiolo and Marsabit Counties in northern Kenya. The goal of Nawiri is to sustainably reduce persistent acute malnutrition by designing and implementing an approach for supporting, strengthening, and protecting systems and institutions. Nawiri is designed to allow for research and learning to directly inform program implementation. Thus, Nawiri has commissioned multiple desk studies to better understand the state of the evidence in the Kenyan ASALs and make sure primary research and program implantation builds on the existing evidence while addressing any identified gaps. This desk study focuses on the drivers of acute malnutrition as identified through research in Marsabit and Isiolo Counties, as well as neighboring ASAL counties in Kenya with a similar climatic context.

Conceptual framework for drivers of malnutrition in drylands

Nawiri has adapted an amended framework of the 1990's UNICEF conceptual framework on the causes of malnutrition (UNICEF 1990) specific to dryland environments (Figure 1). The framework lays out the immediate (inadequate dietary intake and disease) and underlying (insufficient household food security, inadequate household social and care environment, and insufficient health services and unhealthy environment) drivers of acute malnutrition, unchanged from the original UNICEF framework. The amended framework expands on the basic drivers: livelihoods, formal and informal institutions, and seasonality and environment (Young 2020). For this desk study, we document the existing evidence base on the immediate and underlying causes of child malnutrition as defined by both the original and amended conceptual framework for drylands. This desk study is part of a Nawiri desk study series that addresses each level of the conceptual framework for drivers of malnutrition in drylands, including:

- Acute malnutrition hotspot analysis in Marsabit and Isiolo (Ocholo 2021a; Ocholo 2021b);
- Immediate and underlying drivers: the immediate and underlying drivers of child malnutrition in the Kenyan ASALs (this study);
- Basic causes:
    - Livelihoods and nutrition (Stites 2020);
    - Gender gap analysis (Stites and Dykstra-McCarthy 2020);
    - Natural resource management and nutrition (Birch 2020);
    - Climatic variability, disasters, conflict, and nutrition in the Kenya ASALs (Marshak and Venkat 2021).

Figure 1. Nutrition causal framework for drylands.



Desk study methodology

Only studies that utilized a measure of child malnutrition, either self-reported or anthropometrically defined[1] across the ASAL counties in Kenya were included in the literature review for the purpose of comparability. While Marsabit and Isiolo Counties were the priority for the desk study, given the low availability of literature we expanded our search to include additional Kenya ASAL counties that show similar rainfall, temperature, and vegetation patterns as Isiolo and Marsabit, including Garissa, Mandera, Samburu, Tana River, Ijara,[2] Turkana, Wajir, Machakos, and Mukuenic Counties. Of all the counties, the majority of the reported research comes from Marsabit (seven papers) and Turkan (six papers) Counties.

We also included any literature on Kenya as a whole. While the majority of the literature is peer-reviewed, we also allowed for the inclusion of reports written by internationally recognized agencies such as the Food and Agriculture Organization (FAO) of the UN. All literature is based on either primary or secondary data analysis, with no inclusion of literature reviews or availability of meta-analyses. We did not set a start date and explored all electronically available literature, with our earliest paper coming from 1982. In the end, we ended up with 23 papers that were reviewed for this desk study (see Annex A for the list of papers, locations, year of data collection, and nutrition outcomes).

Layout

For the remainder of the report, we focus on the findings of the literature review, starting with a discussion around the indices used to measure the malnutrition, the scope of the problem, a review of the evidence base by category of drivers as outlined in the amended nutrition conceptual framework, followed by a discussion section, and ending with a brief conclusion and implications for the Nawiri program research.

[1] Weight-for-height z-score (WHZ), mid-upper arm circumference (MUAC), wasting (WHZ < -2 or MUAC < 135), height-for-age z-score (HAZ), stunting (HAZ < -2), weight-for-age z-score (WAZ), underweight (WAZ < -2), and upper-arm fat area (UAFA).

[2] Ijara was formerly a district and is now a sub-county within Garissa County.

Defining malnutrition

In this section, we very briefly describe the different nutrition indicators used to discuss and measure child malnutrition, and explain the cut-off points and indicator thresholds and the difference in interpretation depending on whether the outcome is the prevalence of child malnutrition, mean z-score (that is used to calculate prevalence), or the frequency distribution of z-scores.

The World Health Organization (WHO) identified wasting and stunting as two categories of growth failure that are measured anthropometrically by comparing a child's body measurement to growth standards. The two categories of growth failure include wasting and stunting; underweight is a compositive indicator of these two growth failures. While stunting and underweight are frequently used as indicators to measure development progress, wasting is considered to be a short-term phenomenon and thus reflect recent changes in nutritional status and potentially acute problems (WHO 1995). The three measures account for 12.6%, 14.8%, and 18.8% of disability-adjusted life-years lost in children under the age of 5 years with respect to stunting, wasting, and underweight respectively (Black, Victora et al. 2013). The prevalence of wasting and nutritional oedma in a population—global acute malnutrition (GAM)—is used as an indicator of a humanitarian emergency. For example, the Integrated Phase Classification (IPC) uses the prevalence of wasting and severe wasting, along with food security and availability, to determine the severity of a humanitarian emergency and need for intervention. Prevalence of wasting of 15% or above is one of the variables (in combination with measures of food security) that is used to classify an emergency situation.

While the main interest of this study is acute malnutrition, we review papers in this study that use any anthropometric or self-reported measure of nutrition due to the dearth of studies focused on acute malnutrition (making this a rather short desk study) (Brown, Backer et al. 2020; WHO 2020), and also because associations with other nutrition outcomes can provide some insight. While we do not believe that the drivers of stunting, wasting, and underweight are the same, there is some research that highlights the significant overlap in drivers across outcomes (Akombi, Agho et al. 2017). However, as this desk review indicates, we need to be careful to extrapolate findings associated with stunting to wasting.

When measuring child malnutrition, there is a distinction between nutrition indices and nutrition indicators:

- **Nutritional indices**—combinations of measurements compared to a reference population or growth standard expressed as a z-score, percent of median, etc., for measuring nutritional status;
- **Nutrition indicators**—refers to the use of or application of indices, e.g., used to calculate proportion of kids falling below a "cut-off point" corresponding to different degrees of growth failure: wasting, stunting, and underweight (WHO 1995).

Where an indicator stands as a proxy for aspects of growth failure, a child is classified as being stunted if their height-for-age z-score (HAZ) is below −2 standard deviations and wasted if their weight-for-height z-score (WHZ) is less than −2 standard deviations or if that child has edema. Wasting is also classified using a mid upper-arm circumference (MUAC) less than 12.5 cm. Underweight is defined as having a weight-for-age z-score (WAZ) below −2 standard deviations and can be due to either wasting or stunting, or both, and thus is interpreted as a composite indicator (Table 1).[3]

[3] The reference WHZ, HAZ, and WAZ distribution against which children are measured was developed by WHO in 2006 based on the growth standards for attained weight and height from breastfed infants and appropriately fed children of different ethnic origins raised in optimal conditions and measured in a standardized way (WHO 2006). Specifically, data were collected from children in Brazil, Ghana, India, Norway, Oman, and the United States. The WHO growth standards were put in place in 2006 and replaced the National Center for Health Statistics (NCHS)/WHO growth standards.

Table 1. Variable definition

type	variable	definition
nutritional index	WHZ MUAC WAZ HAZ	weight-for-height z-score unadjusted mid upper-arm circumference (cm) weight-for-age z-score height-for-age z-score
nutritional indicator	wasting severe wasting underweight stunting	weight-for-height z-score < −2 mid upper-arm circumference < 12.5 cm weight-for-height z-score < −3 mid upper-arm circumference < 11.5cm weight-for-age z-score < −2 height-for-age z-score < −2

Besides distinctions in what the different z-scores measure—acute vs. chronic vs. composite malnutrition—there are also important distinctions to note between the continuous and binary form of each of these measures (i.e., wasting vs. WHZ; stunting vs. HAZ, underweight vs. WAZ). While all papers in this review looked at child malnutrition, the continuous and binary form of the different measures of malnutrition were frequently used interchangeably even though they tell you very different things about the population. The continuous z-score or MUAC describes the nutritional status of the entire population, while the binary form only tells you something about the very left-hand part of the distribution based on a set cut-off. Thus, changes in the z-score imply that the entire distribution has shifted and suggests that most, if not all, individuals have been affected. The binary form of the variable, on the other hand, is more useful in assessing the severity of a situation. However, for the binary form, it is worth noting that the −2 and −3 standard deviation cut-offs are largely arbitrary and simply reflect the conventional statistical grouping of prevalence levels used across nutrition and health outcomes more broadly. Thus, a child who has a, for example, WHZ of −1.99 would be classified as not wasted, while a child with a WHZ of −2.01 would be. Moreover, there is evidence that population-level distribution of nutrition outcomes is shifting (Penman and Johnson 2006), which would change the actual weight and height characteristics of the children who fall below the threshold if the international growth standards are updated. So, it is important to remember that the thresholds themselves are artificial constraints.

Depending on the outcome, it is possible that different drivers will be identified. For example, a study in Chad showed that when using WHZ as the main outcome indicator, food insecurity was a critical predictor of population-level movements; however, when the same exact model was run on wasting as a binary outcome, food insecurity was no longer significant (Marshak, Young et al. 2021).

Scope of the problem

In this section we look at the scope of the problem of child nutrition across the literature, highlighting the consistency of findings on poor nutritional outcomes. We also briefly touch upon the growing issue of the double burden of malnutrition in Kenya, with households having both an overweight and stunted member. Finally, we present the evidence around the role of sex and age in child nutrition outcomes.

What comes out clearly in the literature review is that poor child malnutrition is a serious and persistent problem in the Kenya ASALS, but also that it is extremely variable (Table 2). In Table 2 we pulled out information on prevalence of wasting, stunting, and underweight from the papers that provided it. While the studies were not representative of the counties, and hence this data cannot be used to extrapolate trends over time or by county, it does show the variability and persistence of poor nutrition.

The findings from the literature, while not representative, do echo the analysis completed by Kenyatta University looking at hotspots of acute malnutrition in Isiolo and Marsabit Counties. The desk study illustrates the severity of the consistently high prevalence of acute malnutrition in this region. Over the last ten years (2010 to 2020), encompassing 13 Standardized Monitoring and Assessment of Relief and Transitions (SMART) survey data collections, Isiolo County has had four periods of "critical" (15–29.9%) levels of acute malnutrition, six periods of "serious" (10–14.9%) levels of acute malnutrition, and three periods of alert (5–9.9%) levels of acute malnutrition as defined by the IPC (Ocholo 2021a). However, all three of the alert levels were above 9%. When disaggregating the data further, with the understanding that there are significant limitations to that disaggregation,[4] some wards in Isiolo present prevalence levels of 30% and above. Marsabit fares similarly, with "critical" levels of acute malnutrition in 7 out of 14 SMART assessments in the past 10 years (2010–2019), with only three assessments in which the GAM prevalence drops below IPC category 3 "serious" at 8.6% in July of 2012, 7.7% in August of 2014, and 5.1% in September of 2014. As with Isiolo, further disaggregation shows that some sub-counties, such as North Horr and Laisamis, are almost consistently at 20% GAM or above (Ocholo 2021b).

The issue of persistent acute malnutrition (P-GAM) is not specific to the Kenya ASALs but has been identified as a serious problem across Africa's drylands (Young and Marshak 2017). Interviews across multiple nutrition stakeholders identified 25 countries, most of them in Africa's drylands (including Kenya), as places where P-GAM is widely recognized as an issue, despite ongoing humanitarian and development interventions. The widespread scale and long-lasting nature of persistent emergency levels of acute malnutrition means that there needs to be a shift in how policy and programming aims to address acute malnutrition.

While undernutrition is a clear problem in Kenya's ASALs, there is also some evidence that the prevalence of overnutrition and obesity is also a growing problem in the adult population. A 2015 representative study showed that almost 9% (confidence interval (CI): 3–27) of adults in Marsabit were overweight and 23% (CI: 5–60) were overweight in Isiolo County (Mkuu, Barry et al. 2021). The literature further suggests that the growing issue of obesity might be contributing to the double burden of malnutrition on the household level, meaning having both an

[4] Disaggregation below county level is problematic as the SMART survey is designed to be representative at the county level. Thus sample size and representation drop off dramatically as the data are used for lower enumeration areas.

Table 2. Prevalence of wasting, stunting, and underweight from the literature by county and year

location and reference	year	wasted (%)	stunted (%)	underweight (%)
Turkana (Brainard 1990)	1990	36	20	34
Turkana (Shell-Duncan and Wood 1997)	1991	6 wet; 10 dry	12 wet; 5 dry	27 wet; 22 dry
Turkana (Shell-Duncan 1995)	1995	26	4	
Marsabit (Shell-Duncan and Obiero 2000)	1996	9–18	26–59	
Marsabit (Miller and McConnell 2012)	2009		18	15
Kenya (Masibo et al. 2012)	1993 – 2009		35–40	16–19
Samburu (Iannotti and Lesorogol 2014)	2012		42 (0–2 yr); 22 (3–5 yr)	34 (0–2 yr); 15 (3–5 yr)
North Rift arid and semi-arid lands (Harison, Boit et al. 2017)	2014	22	23	33
West Pokot (Mutegi and Korir 2016)	2015		46	

overweight and stunted household member. For example, a study looking at changes in trends of covariates of stunting across four rounds of Demographic and Health Surveys found that while in the initial rounds (1998 and 2003) having an overweight adult was correlated with a lower risk of a stunted child, the trend shifted over time. In 2008/9, children with an overweight or obese mother were significantly more likely to be stunted (Masibo and Makoka 2012). Miller (2014) hypothesizes in her research that the growing trend in overweight/obesity could be due to the thrifty gene hypothesis.[5] In their research on infants in Marsabit, the researchers found that

[5] The thrifty gene hypothesis suggests that individuals born into low food security conditions have greater fat storage in order be able to mitigate the effects of famine. Thus, when these individuals are then introduced to a high-calorie diet, they are more likely to accumulate fat than a population with the same diet but who were not born into food-insecure conditions.

despite evidence of stunting, children exhibited increasing upper arm fat levels with age, indicating the fat stores were not being mobilized for linear growth (Miller 2014).

Besides the consistency of high levels of malnutrition in the study, the literature also consistently identified boys as having significantly worse nutrition outcomes when compared to girls (Brainard 1990; Masibo and Makoka 2012; Miller and McConnell 2012; Miller 2014; Bauer and Mburu 2017). This finding corresponds to recent research identifying boys as more vulnerable to poor nutrition outcomes globally. A recent meta-analysis found that boys had a higher odds of being wasted, stunted, and/or underweight compared to girls, and this the difference was stronger in Africa compared to South Asia (Thurstans, Opondo et al. 2020).

However, there were some interesting caveats to the sex-disaggregated analysis. For example, one study went one step further and looked at birth order and sex, and found that first-born sons actually have significantly higher WHZ (Shell-Duncan and Obiero 2000). The recent participatory study in Marsabit also made an interesting observation, finding that "Most Rendille women focus group discussants indicated that they had observed that boys of all ages were more vulnerable than girls and became more malnourished, whereas women from Samburu-speaking groups stated that there was no difference in malnutrition between boys and girls. The Rendille women were not, however, able to explain why boys were more vulnerable to malnutrition than girls. The differences in response between these two ethnic categories might be explained by the understanding that the Rendille might be able to discern a gendered pattern of malnutrition because they occupy a drier ecosystem (Korr and Kargi) and experience more severe droughts and more pronounced malnutrition than the Samburu, who occupy less austere ecosystems (Laisamis and Lontolio)" (FAO, UNICEF et al. 2020, p. 40–41). Only two studies that looked at sex reported no differences in nutrition status (Shell-Duncan 1995; Fratkin, Roth et al. 2004). Moreover, Fratkin, Roth et al. found that while sex was not significant, the directionality of the sign shows that girls are more likely to be underweight. Both of these studies had longitudinal data collection and thus could indicate that timing of data collection matters; there are certain times of year when boys have worse nutritional status, but there is no difference overall. This finding would be in line with recent research out of Chad showing significant seasonality for boys, with times of year when their prevalence of wasting is above 30%. However, on average for the year, there was no difference between boys and girls across all nutrition indicators (Marshak, Young et al. 2021).

Along with sex, there were also significant differences by age. Most studies found that older children had worse nutritional outcomes, when it comes to stunting and underweight, but no difference in wasting. One study found that older children (> 36 months) were more likely to be stunted, but found no difference in wasting (Shell-Duncan 1995). The same author in a later study found a similar finding: among children 6 months to 10 years of age stunting and underweight prevalence was higher for older children, but there was no difference in wasting prevalence (Shell-Duncan and Wood 1997). Bauer and Mburu (2017) also identified older children as more vulnerable among children 6 months to 5 years of age (Bauer and Mburu 2017). Two additional studies specifically identified the period around 2 years (24–35 and 20–23 months respectively) as the period of greatest nutrition risk when it comes to stunting and underweight (Adeladza 2010; Masibo and Makoka 2012). Only one study found some differentiation from this trend: among children 1 to 10 years of age, younger children tended to have worse WAZ scores but better WHZ scores (Brainard 1990). The findings around the lack of age differentiation in regard to wasting are surprising. In the broader nutrition literature, children under the age of 6 months tend be significantly more likely to be wasted (Alderman and Headey 2018). WHZ tends to decline from birth and reach its nadir at around 12 months and slowly improves thereafter; this is consistent with an improved immune system among older children that diminishes the impact of infection on the child's weight (Victora, de Onis et al. 2010; Richard, Black et al. 2012). However, it is a bit difficult to compare the role of age across the ASAL studies given the very different age groups included. For most studies, age was simply included as a continuous variable in the analysis, and prevalence data were not presented by age groups.

Evidence base on drivers of acute malnutrition

In this section we review the evidence base related to the drivers of acute malnutrition, using the amended nutrition framework as an organization guide. We start by discussing the evidence base related to the immediate drivers—child dietary intake and disease—and then we move onto the underlying drivers—household food security, social and care environment, health services, and an unhealthy environment. We also discuss the evidence base around education levels of the household head and caretaker as well as household wealth as enabling factors related to the underlying drivers. Drivers related to the basic causes are covered across four other desk studies: natural resource management (NRM) (Birch 2020); gender (Stites and Dykstra-McCarthy 2020); livelihoods (Stites 2020); and climatic variability, disasters, conflict, and nutrition (Marshak and Venkat 2021).

Immediate drivers—inadequate dietary intake

Four studies explored the role of food intake in child nutritional outcomes (Fratkin, Roth et al. 2004; Iannotti and Lesorogol 2014; Manners, Calo et al. 2015; FAO, UNICEF et al. 2020). All four studies specifically focused on milk intake as their measure of dietary intake, partially drawing on the hypothesis or responding directly to the hypothesis that the sedentarization of pastoralist communities leads to less access to livestock, and hence less milk intake by children, resulting in worse nutrition outcomes. Thus, while it is already difficult to generalize from only four studies, it is even more difficult to make a broad statement on the relationship of dietary intake and nutrition outcomes, when dietary intake is almost exclusively captured as milk consumption. Part of the broader relationship with consumption might be captured when looking at household food insecurity (under underlying cause—insufficient household food insecurity). In this section we present the limited evidence around the link between milk intake and nutrition outcomes in the Kenya ASALs, followed by a very brief discussion around sedentarization, given that it is part of the narrative about why dietary intake is exclusively looked at as milk intake (for a more in-depth review of the link between livelihoods and nutrition, see the livelihood systems desk study (Stites 2020)).

Two studies in the literature review took a participatory approach to identifying dietary intake, specifically animal or human milk, as key drivers of child malnutrition according to the communities. Specifically, the studies identified "low intake of mother's milk and poor access to milk and meat from livestock" in Marsabit (FAO, UNICEF et al. 2020) and "poor access to appropriate age-specific foods, including milk in the dry season" in Isiolo (Manners, Calo et al. 2015). However, while in quantitative surveys we can rely on anthropometry values to define child nutrition outcomes, in participatory studies it is critical to understand how malnutrition is defined and malnutrition risk understood by the communities who are self-reporting the drivers. While the Manners, Calo et al. (2015) study unfortunately does not provide this information, the FAO study does:

> Throughout this study, the definition of malnutrition (undernutrition) was on the bases of local community understanding of the condition and community members' description of malnutrition presentation in children and women. Through the initial discussions with the community during key informant interviews, definitions of undernutrition developed by the community were as follows: Child malnutrition was associated with weakness due to prolonged

lack of adequate food, insufficient quantities of mother's breast milk (i.e. prolonged and continuous hunger), wasting and loss of weight, and lack of playfulness. The child may develop a distended abdomen and lack of appetite and may be susceptible to intestinal worms and other diseases." (FAO, UNICEF et al. 2020, p. 5)

While there is nothing wrong with this definition, the concept of poor dietary intake as a driver is directly imbedded in the definition of child malnutrition, thus making this definition of malnutrition slightly suspect for identifying drivers of malnutrition. It will be important to review with the communities their perception of risk of child malnutrition, particularly in relation to severe versus moderate malnutrition. For example, a study in coastal Kenya looking at perceptions of childhood undernutrition found that households did not consider moderate acute malnutrition (MAM) as a health problem (Muraya, Jones et al. 2016), making the identification of risk factors for MAM by the community more difficult.

Two quantitative studies also looked at milk intake as a driver of nutritional outcomes but found different results. A study in Marsabit found that the number of cups of milk consumed in the past 24 hours was significantly correlated with a lower risk of both stunting and underweight (Fratkin, Roth et al. 2004). The authors did not look at wasting. However, Iannotti and Lesorogol (2014) found that "child milk intake levels[6] were not found to be significantly predictive of any of the anthropometric outcomes" (Iannotti and Lesorogol 2014, p. 71). A recent meta-analysis using Demographic and Health Survey (DHS) data from 1990 to 2017 in low- and middle-income countries, with over half a million individual child observations, suggests that animal milk consumption is associated with a reduced probability of being underweight by 1.4 percentage points, a reduced probability of being stunted by 1.9 percentage points, and that the association with wasting is not robust. Interestingly, the authors find that the association is stronger for children in wealthier households, and thus hypothesize that milk consumption might be a proxy for better overall nutrition and socioeconomic status (Herber, Bogler et al. 2020). Thus, the evidence from the Kenya ASALs mimics the findings from the meta-analysis suggesting a role for animal milk consumption in relation to stunting and underweight, with no evidence on the relationship with child wasting or WHZ.

As noted above, the papers that looked at the relationship between milk intake and child nutrition primarily did so as part of the narrative that sedentarization results in a lower presence of animals and hence less milk intake. Thus, we briefly note the evidence base around sedentarization from which the evidence base on milk consumption was taken. There is no consensus in the research on the role of sedentarization, with one study finding no relationship, another study finding children in pastoral communities better off, and a third study finding significant differences in nutrition outcomes by livelihood, but inconsistent relationships across age and nutrition indicator. The difference in findings likely indicates that sedentarization is not the same process for all communities, households, or individuals; some sedentarize or have part of the household sedentarize because of better opportunities available near urban centers, others because they lost their livestock and are likely involuntary pastoral dropouts, and yet others because of years of missionary work and support that encouraged sedentarization (see livelihood systems desk study (Stites 2020)). Thus, it is hard to generalize about what "sedentarization" is. Therefore, we only report on studies that specifically used the term sedentarization, even if different authors might have a different understanding of what it this term implies.

One study using livelihood zones (FEWSNet) as the basis for geographic comparisons (Grace, Davenport et al. 2012) found that HAZ varied widely by livelihoods. But most studies explored more specifically the question of whether the sedentarization of pastoralist populations results in worse nutrition outcomes. In Turkana District, researchers found a difference in the weight,

[6] Milk consumption was based on a 24-hour recall.

height, triceps, and arm circumference across children in nomadic and settled communities. While nomadic children under the age of 5, specifically boys, were significantly taller than their settled counterparts, children ages 5 to 10 in the settled communities tended to be taller (boys) and have larger triceps (both boys and girls) (Brainard 1990). The authors attributed the distinction by age and livelihood to different diets (milk versus cereal) as well as greater inconsistency in consumption by older children in pastoralist communities. In Marsabit, Fratkin, Roth et al. (2004) found that across all age groups from 6 to 71 months, children in pastoral communities had a lower prevalence of both stunting and underweight (Fratkin, Roth et al. 2004). However, only a few years earlier, another study in Marsabit found no difference in child nutrition outcomes between settled and nomadic communities (Shell-Duncan and Obiero 2000).

Related to the exploration of the impact of sedentarization is the role of livestock and proximity of livestock to women and children (as a proxy for milk access and animal-sourced foods) more generally. Iannotti and Lesorogol (2014) found that household cattle ownership was correlated to better WAZ in children under the age of 5, but not WHZ or HAZ. The same study actually found that maize consumption (associated with sedentary livelihoods) was a more robust predictor of nutritional outcomes, correlated with higher HAZ and WAZ, but still not WHZ (Iannotti and Lesorogol 2014). The 2020 FAO study in Marsabit identified lack of livestock and livestock migration away from the homestead as key drivers of child malnutrition as reported by the community (FAO, UNICEF et al. 2020). An interesting caveat to consider in relation to the relationship between milk consumption and/or livestock ownership and nutrition outcomes is both the seasonality of milk consumption and the variability in that seasonality by different livestock. Goats, sheep, and cows can have very different seasonal patterns in milk production (Wilson, Diallo et al. 1985). Thus, depending on the season of data collection, size of the herd, and herd composition, likely different relationships between milk intake and nutrition will be identified. The Nawiri program research will consider all three characteristics to try to identify if, how, and when the level of animal milk consumption is associated with wasting.

Immediate drivers—disease

Multiple studies explored the relationship between disease and child malnutrition. However, unlike with dietary intake, there is great variability in how disease is captured, including: whether a child was anergic (meaning when the body fails to respond to an antigen) (Shell-Duncan and Wood 1997), acute respiratory infections (Brainard 1990; Shell-Duncan and Wood 1997), malaria (Brainard 1990), salivary immunoglobulin A (Miller and McConnell 2012), diarrhea (Njuguna and Muruka 2011; Masibo and Makoka 2012), number of days ill with either diarrhea, respiratory disease and/or fever in the past 30 days (Fratkin, Roth et al. 2004), and self-reported disease (Manners, Calo et al. 2015; Mutegi and Korir 2016; FAO, UNICEF et al. 2020). Irrespective of how disease was measured or what nutritional outcomes were used, disease was consistently associated with worse nutrition across every study. However, interpretation of these relationships can be difficult given the cyclical nature of disease and child malnutrition (Pelletier, Frongillo et al. 1995).

In Turkana, child underweight and wasting was associated with three times the risk of a child being anergic (Shell-Duncan and Wood 1997). The same study also found that WHZ was negatively associated with individual attack rates of acute respiratory infections (ARI), with a one-unit change in weight-for-height associated with a 9% greater risk of respiratory infections in the wet season and a 68% greater risk in the dry season. MUAC-for-age and WAZ were also associated with a greater risk of ARI, but only in the dry season. In Marsabit, Miller and McConnel (2012) found that higher levels of salivary immunoglobulin A (IgA) were associated with decreased HAZ, but not WAZ or WHZ. The authors interpret this as “indicating that mucosal immune functioning is elevated in infants who are chronically malnourished” (Miller and McConnell 2012, p. 139). Also in Marsabit, number of days ill with diarrhea, respiratory illness, and/or fever in the past 30 days was associated with a greater risk of a child being underweight (Fratkin, Roth et al. 2004). A broader geographical analysis across four different Kenya DHS data sets found having diarrhea preceding the survey was associated with wasting and underweight. Interestingly, while stunting was also significantly associated with diarrhea in the 1993, 1998, and

2003 survey, in 2008 there was no relationship (Masibo and Makoka 2012). In Ijara, diarrhea was associated with lower MUAC (no other nutrition outcomes were tested) (Njuguna and Muruka 2011). A study in Turkana using health survey data found a high prevalence of malnutrition, malaria and respiratory illness, concluding that these disease likely contributed to poor nutritional status in children; however, they never tested for an association (Brainard 1990). Similarly, a study among Turkana children found high levels of immunosuppression year-round against a backdrop of consistent levels of child malnutrition, leading the author to conclude that infection is an important contributor of high levels of nutritional stress, but there was no analysis on the relationship between different variables, just their seasonal patterns (Shell-Duncan 1995). In all three studies using participatory methods, communities identified disease as a driver of child malnutrition (Manners, Calo et al. 2015; Mutegi and Korir 2016; FAO, UNICEF et al. 2020).

Underlying driver—insufficient household food insecurity

While dietary intake was primarily discussed in terms of child milk consumption (see section above), proxies of household food insecurity varied across all (quantitative and qualitative) studies, including household dietary diversity (Bukania, Mwangi et al. 2014), household milk and maize consumption (Iannotti and Lesorogol 2014), and self-reported food security defined as "low food supplies," "poor access to nutritious animal-source feeds such as milk, flood, and meat" (FAO, UNICEF et al. 2020), and just "food insecurity" (Mutegi and Korir 2016). Across the quantitative studies, household food insecurity was associated with long-term impacts—stunting, WAZ, and HAZ—but not short-term impacts on wasting or WHZ.

A study in Machakos and Makueni Counties found that severe food insecurity (using household dietary diversity cut-off points) was associated with stunting, but not wasting or underweight (Bukania, Mwangi et al. 2014). In Samburu, while child-level milk consumption was not associated with any anthropometric outcomes, several household measures of consumption were: household milk consumption was associated with a higher body mass index (BMI) among youths, and household maize consumption was associated with a higher HAZ and WAZ, but not WHZ, in children under 5 years of age (Iannotti and Lesorogol 2014). Two of three studies using participatory methods identified household food insecurity, especially lack of access to animal-source foods, as a driver of child malnutrition (Mutegi and Korir 2016; FAO, UNICEF et al. 2020).

Underlying driver—inadequate social and care environment

Very few studies looked at "inadequate social and care environment," including not a single study using quantitative methods. All three studies using participatory approaches identified the increasing workload of women and its impact on available time to care for young children as a major causal factor of worse nutrition outcomes (Manners, Calo et al. 2015; Mutegi and Korir 2016; FAO, UNICEF et al. 2020).

Underlying driver—insufficient health services and unhealthy environment

While there is a lot more research in the Kenya ASALs on the role of water access, latrine access, and quality of health services, these factors were only explored using either secondary data analysis (the Kenya DHS) or participatory studies. Not a single study collecting primary data explored the link between these drivers and child malnutrition.

Using 2008 DHS data, Grace, Davenport et al. (2012) found that households whose principal water sources were not surface water had a higher HAZ (Grace, Davenport et al. 2012). Harison, Boit et al., using the 2014 DHS data, with a specific focus on five ASAL counties: Turkana, Kaikipia, Baringo, Samburu, and West Pokot, found that access to a safe drinking source was associated with a lower percentage of children being stunted or underweight in a given enumeration area/cluster (Harison, Boit et al. 2017). Another study, also using DHS data, but four rounds of data (1993, 1998, 2003, 2008) found that access to toilet facilities was associated with a significantly lower probability of a child being stunted or wasted (Masibo and Makoka 2012). Poor access to safe water was also identified by Mutegi and Korir (2016) and Manners, Calo et al. (2015) as a driver of child malnutrition (Mutegi and Korir 2016; Manners, Calo et al. 2015).

Access to health services was also explored in the research, but not as frequently as measures of water and sanitation. Using the 2014 DHS data, Harison, Boit et al. (2017) found that place of delivery was significantly associated with the percentage of children underweight or stunted in a given cluster in the Kenya ASALs (Harison, Boit et al. 2017). Using the Link Nutrition Causal Analysis (NCA) approach, Mutegi and Korir (2016) also report that poor health-seeking practices along with low access to health services was associated with higher risk of child malnutrition (Mutegi and Korir 2016). Finally, a study in Garissa found that the quality of available health services when it comes to appropriate management of children with severe acute malnutrition at the hospital was extremely low, with adherence to only five out of the eight steps specified by the Ministry of Health (MoH) guidelines (Warfa, Njai et al. 2014).

One article touched on the role of stigma in seeking health services for malnourished children. The researchers found that in Marsabit County having a child with moderate or severe acute malnutrition negatively reflected on the child's mother and household, with shame being listed as one of the 10 most frequently mentioned barriers to seeking health services, and the only one (according to the analysis) felt significantly more if the mother had an acutely malnourished child (Bliss, Njenga et al. 2016).

Additional drivers: education and wealth

In this section, we review the evidence base around education and wealth. Both of these drivers are assumed to create the enabling environment for the underlying drivers, such as increased ability to utilize health services, purchase a diverse and smoothed (across the year) diet, greater acceptance of formal as opposed to informal health services, greater access to and utilization of latrine and potable water sources, etc. In general, we find that education level of the household head, and more importantly of the female caretaker, is associated with better outcomes, while the evidence base around wealth is more mixed. Interestingly, there is some evidence that the role of both of these indicators on wasting has declined over time in the ASALs.

The education level or literacy of the household head was associated with improved nutrition outcomes (Bauer and Mburu 2017; Harison, Boit et al. 2017). A few articles specifically focused in on the mother's education and also found an impact on child outcomes. A child with a mother who had completed primary or secondary school had significantly lower levels of stunting and higher WAZ respectively (Adeladza 2010; Grace, Davenport et al. 2012). An analysis of four rounds of DHS data found that having an uneducated mother (as opposed to a mother with secondary education or above) was associated with about a 1.7% increase in the odds of a child being stunted and 2.3% increase in being wasted in the first three surveys evaluated. Interestingly, in the 2008/9 DHS data, the odds of a child being stunted was associated with mothers who had below a secondary level of education (rather than no education), likely indicating the increase in educated mothers given the policy of universal primary education (Masibo and Makoka 2012). The changes in significant reference category (i.e., what you are comparing to in a regression analysis) on mother's education could indicate that education is important but also a more general proxy for women's opportunities, and hence having primary education when few women had any in the earlier surveys is equivalent to having above primary education in the later surveys.

Household wealth was either derived through indexes or self-reported.[7] These measures of wealth were some of the most commonly tested drivers explored in the literature, alongside disease and food consumption/security. Findings on the relationship between wealth and nutrition outcomes are mixed, with three

[7] Common indices of wealth used throughout the papers are a combination of asset and livestock ownership. When it comes to livestock ownership, Tropical Livestock Units are frequently used, whereby each livestock is given a score based on relative prices at the market. Self-reported wealth is when households are asked to rank their wealth compared to the rest of the community.

quantitative studies finding an association, two participatory studies finding an association, and three quantitative studies finding no association. Moreover, not a single study found an association with a measure of acute malnutrition: wasting or WHZ.

Using the 2014 DHS data, but only for ASAL counties, the authors found that the poverty index (based on asset ownership) was correlated to a lower prevalence of stunted or underweight children in an enumeration area/cluster (Harison, Boit et al. 2017). Similarly, analysis across all of Kenya using four rounds of DHS found that in the first two rounds of data collection (1993 and 1998) children in the wealthiest quintile were significantly less likely to be stunted, but no difference was observed between the lower quintiles. However, in 2003 and 2008, the only significant difference in stunting was observed between the richest and poorest quintile, and no differences were observed between the middle quintiles and the most extreme quintiles, indicating a declining role of wealth in relation to stunting. Furthermore, no relationship between wealth and wasting was identified across the four different DHS datasets (Masibo and Makoka 2012).

In Marsabit, self-reported economic status found that households from the poorest group were significantly more likely to have an underweight or stunted child (Fratkin, Roth et al. 2004). Two of the three participatory studies identified "wealth" and "low sources of income" as drivers of child malnutrition (Mutegi and Korir 2016; FAO, UNICEF et al. 2020).

However, the remaining studies found no relationship with wealth, irrespective of how it was measured. A study in Marsabit done only a few years earlier than Fratkin's study (also looking at both nomadic and sedentary households) found no relationship between nutrition outcomes and multiple different proxies of wealth, including garden size, agricultural production, marketing, livestock holdings measured using Tropical Livestock Units (TLUs), cash income, cash equivalence of agricultural products, as well as self-reported economic status (Shell-Duncan and Obiero 2000). There was one exception to the lack of significance: the inclusion of an interactive term between having a female-headed household and lower economic status did indicate a significant association with lower WHZ. Similarly, Bauer and Mburu, also conducting work in Marsabit, found no relationship between nutrition outcomes and income diversity, total income, livestock diversity, or TLU (Bauer and Mburu 2017). Miller (2014) also found no relationship between wealth, as measured in household livestock ownership or as self-reported wealth status, and child upper-arm fat area (UAFA) (Miller 2014). These findings are in line with recent research (using multi-country DHS data, including Kenya) that shows that about three-quarters of underweight woman and undernourished children are not found in the poorest 20% of households, and around half are not found in the poorest 40%. One of the explanations provided by the article is the covariate nature of some of the risk factors for poor nutrition. Using the same DHS data, the authors show how similar the prevalence of diarrhea, blood in the stool, and fever are across wealth groups, with even high-wealth households having a significant exposure to disease (Brown, Ravallion et al. 2019).

Discussion

In this section, we present key discussion points based on the literature review. We start by returning to the issues under the scope of the problem, then discuss the main assumptions and respective evidence base around drivers of child malnutrition, and finally highlight some aspects missing from the literature more broadly.

Scope of the problem

While there are few definitive statements we can make around drivers of acute malnutrition from this desk study, what we can say is that acute malnutrition is a persistent problem in the Kenyan ASALs, but also, clearly, an under-studied problem. Less than half (10) of the studies reviewed specifically looked at measures of acute malnutrition (WHZ, MUAC, wasting defined by WHZ or MUAC). The limited research on wasting is not just an issue in the Kenya ASALs, but also more globally. A systematic review by Brown, Backer et al. (2020) similarly identified wasting as the most under-studied nutrition indicator (Brown, Backer et al. 2020).

Another key finding related to the study of wasting is that we cannot necessarily generalize drivers of stunting and underweight to drivers of wasting. For several of the key drivers such as milk intake, household food security, and wealth, the desk review identifies an association with stunting and HAZ, but not wasting. The lack of a relationship of wasting with wealth and/or milk intake was also identified via larger systematic reviews and meta-analysis (Brown, Ravallion et al. 2019; Herber, Bogler et al. 2020). However, the two outcomes are strongly associated, with some research identifying a temporal link between wasting and stunting, with children who are wasted having an increased subsequent risk of becoming stunted. Four decades of growth monitoring in rural Gambia provides evidence that stunting is part of a biological response to previous episodes of wasting (Schoenbuchner, Dolan et al. 2019). A similar longitudinal relationship between wasting and stunting was found when analyzing eight observational cohort studies across Peru, Brazil, Guinea-Bissau, Bangladesh, and India (Richard, Black et al. 2012). Thus, efforts in preventing wasting are likely to have knock-on effects on stunting prevalence.

Another fairly consistent finding is the differentiation of nutrition outcomes by sex. Almost every (non-longitudinal) study identified boys as more vulnerable to poor nutrition outcomes. This finding is in line with the wider literature. Numerous studies have reported worse outcomes for boys in regard to stunting (Svedberg 1990; Wamani, Astrom et al. 2007; Black, Victora et al. 2013), underweight, wasting, and under-5 mortality (Svedberg 1990; Black, Victora et al. 2013) in the Sahel as well as in Southeast Asia (Harding, Aguayo et al. 2018). A review of unweighted mean rates of wasting across 80 countries showed that boys were consistently significantly more likely to be wasted (Development Initiatives 2018). However, despite the consistency of these findings, there is not a single study in this desk study that looked at how drivers might differ for boys versus girls. An additional complication is the lack of significant differences by sex in the two longitudinal studies. Thus, without additional sex-disaggregated longitudinal research it is difficult to say if the observed difference is partially related to seasonality and hence only captured in cross-sectional studies (Marshak, Young et al. 2021) or whether programs need to focus on different drivers for girls and boys.

An unexpected finding relates to nutrition outcomes by age group. While nutrition outcomes are known to vary by age, the patterns identified in the ASAL literature showing older children to be more susceptible to poor nutrition outcomes is unexpected. The usual trend for WHZ is that it usually hits its lowest point around 12 months, likely due to the improved immune system among older children (Victora, de Onis et al. 2010; Richard, Black et al. 2012). However, some research has found that in severe food insecurity or famine conditions, the proportional increase in wasting and mortality tends to be greater among older kids. Young and Jaspers (1995) hypothesize that this might be because older children no longer have the added protection of breastfeeding or are not supported in the same way with supplementary feeding during relief programs (Young and Jaspers 1995). While it is difficult to discern if this might be the case in the ASALs, given the lack of consistent reporting of prevalence and mean z-score data by age group, the trends across age group need to be further explored.

Assumptions versus the evidence base

In this section, we present a summary of some of the key assumptions identified in the literature as well as the respective evidence base. We specifically focus in on the role of food security, wealth, and sedentarization on child nutrition outcomes. Interestingly, all three of these drivers are part of the same narrative that runs through much of the literature on malnutrition in the Kenya ASAL: that reduced animal milk consumption is the main driver of child malnutrition, and hence sedentarization is associated with worse nutrition outcomes as it means less access to milking animals. The narrative goes on to state that wealth determines a household's ability to access food and animal-based products in the first place, and thus poorer households have worse nutrition outcomes.

Food security and consumption

Six studies looked at household food security or dietary milk intake as a possible driver of child nutrition outcomes. All three of the participatory qualitative studies highlighted the importance of household food security and particularly child milk intake (Manners, Calo et al. 2015; Mutegi and Korir 2016; FAO, UNICEF et al. 2020). However, among the quantitative research, the findings were more mixed. In one study, household food security was associated with stunting, but not wasting or underweight (Bukania, Mwangi et al. 2014). Milk intake in another study was associated with stunting and underweight (but there was no reported evidence on wasting) (Fratkin, Roth et al. 2004). A third study found no relationship between child milk intake and any nutrition outcome (including WHZ and wasting), but did find that household food consumption of milk and, more so, maize was associated with HAZ, WAZ, and BMI (Iannotti and Lesorogol 2014). The lack of an association with wasting corresponds to a recent meta-analysis showing a consistent relationship between milk consumption and stunting and underweight, but not wasting (Herber, Bogler et al. 2020).

Despite the inconsistent evidence base, food insecurity, and specifically milk intake from livestock, was consistently identified as a critical driver with programming implications. For example, while Iannotti and Lesorogol (2014) reported that "child milk intake levels[8] were not found to be significantly predictive of any of the anthropometric outcomes" (Iannotti and Lesorogol 2014, p. 71), the title of the article is "Animal milk sustains micronutrient nutrition and child anthropometry among pastoralists in Samburu, Kenya" with a clear recommendation that "program and policy support to sustain and increase milk production among the Samburu and other pastoralists could help ensure young child and youth nutrition" (p. 74). Another study in Turkana looking at the prevalence of child malnutrition in relation to different diseases, but with no data on any measure of food intake, makes this recommendation in the end: "Availability of a high protein supplement, such as animal milk, for the younger children should be coupled with educational efforts aimed at mothers and caretakers to ensure that the especially high energy and protein needs of young children are being met." (Brainard 1990, p. 160–161). In another study, stunting served as a measure of "child hunger," with the conceptual framework that shows stunting at the top, with "food utilization," "food availability," and "food access" as the main drivers of stunting and key mediators between

[8] Milk consumption was based on a 24-hour recall.

the input variables in the analysis (remote sensing data on temperature and precipitation) and the outcome variable stunting. The study finds a significant relationship between HAZ and precipitation, leading the researchers to make the following recommendation: "In sum, investments made to ensure that all households have access to culturally relevant and nutritional food will contribute to the long term health of Kenya and this investment is especially important in the presence of a drying climate" (Grace, Davenport et al. 2012, p. 412).

There is a disconnect between the inconsistency of the association in the evidence base versus the consistency of recommendations in the papers about organizations supporting food-based programming. Pelletier, Deneke et al. (1995) first recognized this "food-first" bias in Ethiopia when the authors compared the existing evidence base versus the type of programming that was funded and implemented. They found that while the evidence base around food security as the main driver of malnutrition was slim, the primacy of the food-first assumption resulted in an emphasis on food-oriented interventions such as supplementary feeding, agricultural production, market gardens, support for markets and the food value chain, and social and behavior changes around cooking and meal composition (Pelletier, Deneke et al. 1995). All of this is not to say that low milk intake or household food insecurity are not drivers of child malnutrition, but that the evidence base, particularly in relation to milk, does not justify the consistency of a food-first focus in programming around nutrition and requires greater exploration.

Wealth/poverty

Not a single study found an association with measures of acute malnutrition (wasting and WHZ) and wealth. More broadly, findings looking at the association between wealth/poverty and child nutrition outcomes are mixed, with three quantitative studies finding an association, two participatory studies finding an association, and three quantitative studies finding no association. However, similar to food security, there appears to be a predominance of the assumption that malnutrition primarily occurs only in poor households. For example, a recent study in Marsabit included a section in the report called "diets of healthy vs. malnourished children disaggregated by age." The section immediately states, "This question was rephrased to compare foods constituting diets of children from rich and poor households rather than healthy and malnourished children, because sometimes the healthy poor and malnourished poor eat different quantities of similar foods" (p. 41) without changing the name of the section, thus clearly equating wealth with diet (FAO, UNICEF et al. 2020). Other studies extrapolated findings from non-wealth variables to indicate a relationship with wealth. For example, one study finding a significant relationship between water source and education with nutrition outcomes viewed both water and education as simply a proxy of wealth, writing "overall, wealthier, more educated households had lower incidences of stunting regardless of livelihood type and region" (Grace, Davenport et al. 2012, p. 412).

A final point relates to income diversification, which was assumed as a positive indicator, reflecting a diversified income stream and availability of alternative income opportunities (Bauer and Mburu 2017). However, this measure needs to be approached with caution, as it might reflect that households cannot rely on one main source of income such as herding or farming and therefore must cobble together an income across multiple livelihood strategies more akin to coping strategies. For example, we know from the livelihood systems desk study that for better-off households, diversifying into more commercial or monetized endeavors and splitting households across the rural-urban divide can lead to significant benefits and more diversified economic opportunities. However, for households or individuals who migrate to town because they have stepped out of pastoralism altogether and are taking on a mix of casual wage labor, domestic services, and/or sale of natural resources, the result can be less successful, with evidence showing that these activities are insufficient for sustainable livelihoods. Most towns can absorb only a limited number of new entrants (Stites 2020).

A recent paper looked at DHS data from 30 countries (including Kenya) and Living Standards Measurement Studies from eight countries in sub-Saharan Africa. The authors find that aside from a relationship with child stunting, the wealth effect is extremely weak in most countries, with wasting especially showing little or no relationship with wealth. The paper concludes that "We find evidence consistent with the view that covariate risks found in the local health environment help explain why undernutrition in children is spread so widely across the distribution of household wealth in sub-Saharan Africa" (Brown, Ravallion et al. 2019, p. 644).

The inconsistent relationship with wealth could also be simply an indication that asset or livestock ownership is not a sufficient proxy for wealth in these communities. For example, the livelihood systems desk study highlights that, in pastoralist communities in Turkana, poverty is measured by both livestock and people, and true impoverishment only exists for those with a deficit in both. Households that experience significant livestock loss can rely on their social connections, networks, and expectations of reciprocity to recover and rebuild. It is only those with neither livestock nor connections that are truly vulnerable (Stites 2020).

Sedentarization

While sedentarization of pastoralist communities is the starting point of much of the discussion around child malnutrition in the Kenya ASALs, the evidence base itself is inconsistent. There is evidence that sedentarization is associated with fewer livestock, less milk, and more maize consumption (Iannotti and Lesorogol 2014), but the next step in the association with nutrition outcomes is more tenuous. In the literature, we found one study finding no relationship (Shell-Duncan and Obiero 2000), another study finding children in pastoral communities are better off (Fratkin, Roth et al. 2004), and a third study, finding significant differences in nutrition outcomes by livelihood, but inconsistent relationships across age and nutrition indicators (Brainard 1990). The difference in findings likely indicates that sedentarization is not the same process for all communities or households. Some sedentarize because of better opportunities available near urban centers, others because they lost their livestock and are likely involuntary pastoral dropouts, and yet others because of years of missionary work and support that encouraged sedentarization. In addition, according to the livelihood systems desk study, sedentarization can occur within the same household but on gender and generational lines. Households frequently split to take advantage of new opportunities, with women and children moving to the town, leaving males behind in the rural areas to continue livestock production. Thus, these households would be distinct from female-headed households that move to towns following an idiosyncratic shock; yet the two could be difficult to distinguish in a standard survey (see the livelihood systems desk study). Sedentarization is not ubiquitous, and it is hard to generalize what the impact of "sedentarization" generally would be. Shell-Duncan and Obiero (2020) clarify this point: "Limitations of earlier studies highlight two factors that may be salient in understanding the nutritional outcome of sedentarization. First, studies that simply dichotomize settled versus nomadic sectors of a population oversimplify changes occurring during the process of sedentarization, and obscure variation between communities with different subsistence strategies and production systems" (Shell-Duncan and Obiero 2000, p. 184).

What are we missing?

The literature almost exclusively focused on individual- and household-level drivers, with much less consideration of how community-level characteristics might relate to nutrition outcomes. However, it is precisely these community-level factors that might be critical for both explaining the clearly recognized malnutrition hotspots (i.e., clustered cases of malnutrition by community) across Isiolo and Marsabit (Ocholo 2021a, Ocholo 2021b) as well as the distribution of poor nutrition outcomes across wealth categories as identified by Brown, Ravallion et al. (2019). Part of the reasoning is likely methodological—analyzing community-level factors requires a sample with sufficient number of communities—while another part is more directly related to the emphasis of treatment over prevention of malnutrition, which is far more about supporting individuals or vulnerable households rather than communities. A few of the papers did explore the contribution of individual-, household-, and community-level differences to the risk of a child being malnourished. Shell-Duncan and Obiero (2020) found some evidence of clustering of nutrition outcomes (in relation to WHZ) and that individual-level characteristics accounted for 18% of the variation in WHZ, but "Surprisingly, we found that none of the household-level factors,[9] neither alone nor as interaction terms, were found to be significant predictors of WHZ" (Shell-Duncan and Obiero 2000, p. 194). Miller and McConnell (2012) also touch on this and find that "village" as a variable was a significant predictor of infant immunoglobulin A (IgA) (Miller and McConnell 2012).

Another clear omission from the literature is that while several papers recommend support for livestock-related programs and/or look at household-level livestock ownership (usually as a measure of wealth) as a key driver, not a single study considered zoonosis and hence the presence of livestock as a community-level variable. However, as Covid-19 has clearly shown us, zoonosis cannot be ignored and is likely only going to become more prevalent as a risk factor.

Finally, none of the literature presented findings on the interaction of drivers, though Miller and McConnell (2012) did note that they tested interactions but found none of the interaction terms significant. However, it is extremely likely that the presence of more than one driver exacerbates the risk of a child being malnourished, and thus future research needs to both test for interactions and make the findings explicit (even if not significant).

[9] Household-level variables tested included: economic status, maternal education, maternal age, de jure and de facto female household headship, household size, and household type (polygynous versus nuclear).

Conclusion and implications for Nawiri

The evidence base reviewed for this desk study on drivers of acute malnutrition (and other anthropometric outcomes) is extremely slim for drawing very direct conclusions, with a few exceptions. What we can say for certain is that acute malnutrition is a problem in the Kenya ASALs, but its drivers are under-studied, and program recommendations are strongly reliant on assumptions. Thus, the Nawiri research is critical for filling the evidence gap and designing interventions that can prevent acute malnutrition. And while the evidence base is slim, it still offers a treasure trove of information that can be used to improve the design and analysis of the upcoming Nawiri primary data collection, both quantitative and qualitative. We briefly discuss the implications here.

While the aim of the Nawiri research is to understand the drivers of acute malnutrition, how acute malnutrition is defined varies, with arguments for and against WHZ versus MUAC, particularly for populations that practice pastoralism and/or have a high milk intake. Moreover, there are likely some distinctions in what drivers are associated with individual nutritional status measures (WHZ or MUAC measurements) and their nutritional status category (severe wasting, wasting, and well nourished). We can address these issues in multiple ways in the Nawiri research. First, we will collect WHZ and MUAC at each time period in the longitudinal data collection. Second, we will collect the sitting-standing height ratio once a year to determine how comparable children's body shape is in our three groups: primarily "pastoralist," "agropastoralist," and "pastoralist dropouts." We will also make corrections for differences between this population and other growth standards, thus getting a more accurate WHZ measure of wasting in these populations. If we find a significant difference, we can apply the Cormic Index, which is the sitting-height-to-standing-height ratio expressed as a percentage to correct for differences. We do not anticipate that we will find differences in body shape across our three populations; however, we will make sure that this assumption is supported by the sitting-height ratio data. Third, in the analysis, we will consider identifying drivers of both the continuous and binary forms of our outcome, the difference (or not) in identified drivers using MUAC vs. WHZ, and the exploration of using a composite indicator as was done in Afghanistan (Humphrey, Sarker et al. 2019). Finally, we will test for interactions between the different drivers.

Sex and age clearly matter when it comes to distinctions in nutrition outcomes in the Kenya ASALs. Thus, we will follow recommendations from the "Sex and age matter" report (Mazurana, Benelli et al. 2011) and present our data disaggregated by sex and age group. In addition, we will run our analysis separately for boys versus girls to see if we can identify different drivers by sex. We will also more thoroughly explore the finding in the ASALs literature identifying older children as more vulnerable to nutrition outcomes, considering that it is contrary to the assumed norm. Finally, we will explore whether differences by sex and age might be partially explained by different seasonal patterns across these categories, by running an analysis on the combined longitudinal dataset versus individual periods of data collection.

While we did not find any evidence in the Kenyan ASALs that milk consumption or household food security are associated with wasting, we know that there are associations with other nutrition indicators and that availability is seasonal. We will collect quantitative data on whether the child had consumed animal milk in the past 24 hours, whether that consumption is seasonal, and if it is associated with our different acute malnutrition outcomes. We will also consider herd diversity as an indicator of milk availability, considering that different livestock lactate at different times of year (Wilson, Diallo et al. 1985). In addition to milk, we will broadly look at consumption of other food groups, as well as a measure of household food insecurity (using the Household Food Insecurity Access Scale). Given the limitations of both the quantitative child consumption and food insecurity variable, we will also use seasonal calendars and other qualitative methods to determine the seasonality of these hypothesized drivers.

The literature review consistently identified some measure of disease as associated with child nutrition outcomes; however, directionality of that relationship was not discernable. We will collect data on whether the child was ill in the past two weeks, as well as on what the child was ill with (respiratory infection, diarrhea, malaria, and fever). We will look at both the seasonality of these morbidities as well as their relationship with nutrition outcomes. Unfortunately, without extremely granular data (collected at least twice a month) we too will not be able to identify the directionality of these relationships.

We also found that none of the quantitative studies in the literature review looked at the social and care environment, while the qualitative data consistently identified women's workload as a serious constraint. We will try to address this gap via the inclusion of a quantitative variable in our seasonal survey looking at hours spent working by the female care provider. However, as likely other studies have, we recognize the problem with this variable and will also explore this issue through the qualitative methods. Another key variable associated with nutrition outcomes was the education level of the female caretaker. We will capture this information on an annual basis in order to see its relationship with child nutritional status.

The secondary data explored in this literature review also consistently identified access to potable water and latrines as significant predictors of better nutrition outcomes. We will collect data for both of these variables in the quantitative seasonal survey. However, a major gap identified in the literature is that these variables are only looked at for the household level and not for the community level. This is particularly relevant when it comes to the possible role of zoonosis. Thus, we will also assess the degree of community-level sharing of water sources with animals on a seasonal basis. Through qualitative methods we will further explore the seasonal pattern of animal migration in these contexts to better understand when and to what degree these communities come in contact with large herds of livestock. In addition, we will identify key informants in veterinary services to better understand the local seasonality of animal diseases in this context.

The evidence on the role of livelihoods and specifically sedentarization is inconclusive and also problematic. While our quantitative design replicates some of the problems identified in previous literature—simplistic groupings across livelihood categories (pastoralist versus agropastoralist versus dropout pastoralist)—we hope to partially remedy this through historical accounts of livelihood specialization and in-depth interviews about livelihood-related processes and strategies. These accounts and interviews should allow us to better interpret the more simplistic categorical definitions utilized in our quantitative design.

Wealth was another key driver where the assumptions in the literature did not line up with the evidence base, particularly for wasting. We will construct wealth variables using both asset and livestock ownership, as both a combined and separate wealth indicator. Thus, we will aim to determine to what degree (if any) nutrition outcomes vary by household wealth.

Annex A: Literature from the Kenya ASALs covered in this desk study

name	location	year of data collection	seasonality	nutrition outcome
Seasonality of malnutrition: Community knowledge on patterns and causes of undernutrition in children and women in Laisamis, Marsabit County, Kenya	Laisamis Sub-County, Marsabit County	2020	yes—self-reported and monthly	MUAC, child malnutrition (line graph, numbers not reported)
Impact of seasonal variation in food availability and disease stress on the health status of nomadic Turkana children: A longitudinal analysis of morbidity, immunity, and nutritional status	Turkana County	1995	yes—12-month longitudinal study	HAZ (> 36 months): 66.6% normal, 25.9% wasted, 3.7% stunted, 3.7% wasted and stunted; maximum likelihood estimates of regression parameters for an analysis of covariance for repeated measures using z-scores and percent of reference medians from international reference data; WHZ: −1.37, MUAC for age: 96.17, HAZ: −.56981, WAZ: -.89981
Undernutrition risk factors and their interplay with nutrition outcomes: Nutrition causal analysis pilot in Kenya	Isiolo County	2013	yes—self-reported	Qualitative

Child nutrition in the transition from nomadic pastoralism to settled lifestyles: Individual, household, and community- level factors	Marsabit County	Nov 1995/ Feb 1996	no, limitation	Nomad, Korr, Karare, Songa, Marsabit HAZ percent normal 74.0, 41.2, 67.3, 68.1, 65.0 Nomad, Korr, Karare, Songa, Marsabit// HAZ percent stunted 26.0, 58.8, 32.7, 31.9, 35.0 Nomad, Korr, Karare, Songa, Marsabit// WHZ percent normal 88.6, 81.8, 85.6, 85.4, 91.3 Nomad, Korr, Karare, Songa, Marsabit// WHZ percent (mild and severe) 11.4, 18.1, 14.4, 14.6, 8.8 Nomad, Korr, Karare, Songa, Marsabit// MUAC percent normal (> 80%) 90.2, 73.8, 81.6, 81.3, 91.1 Nomad, Korr, Karare, Songa, Marsabit// MUAC percent wasted (< 80%) 9.7, 26.2, 18.5, 18.7, 8.8
Nutritional status and morbidity on an irrigation project in Turkana District, Kenya	Turkana County	1990	no, but mentioned "season"—after harvest—to help interpret results	HAZ (1–4 years): normal, 6%;, 20%; moderate , 33%; severe , 41% WHZ (1–4 yo): normal, 56%; mild , 36%; moderate , 9%; severe (> −3), 0% WAZ (1–4 yo): normal, 6%; mild , 34%; moderate , 37%; severe , 23%
The evaluation of delayed-type hypersensitivity responsiveness and nutritional status as predictors of gastro-intestinal and acute respiratory infection: A prospective field study among traditional nomadic Kenyan children	Turkana County	1990–1991	yes: dry vs. wet	proportion of children 6 mos–10 years suffering from mild to moderate malnutrition: WHZ (wet/dry): 0.06/0.10; WAZ (wet/dry): 0.27/0.22; HAZ (wet/dry): 0.12/0.05; MUAC for age (wet/dry): 0.06/0.17; proportion of children 6 mos–10 years suffering from severe malnutrition: WHZ (wet/dry): 0.03/0.02; WAZ (wet/dry): 0.02/0.02; HAZ (wet/dry): 0.09/0.05; MUAC for age (wet/dry): 0.02/0.02
Cross-sectional growth of nomadic Turkana pastoralists	Turkana County	1981 (Mar and Apr) and 1981–1982 (Dec–Mar)	yes: dry vs. wet, but just took the average	
Mixed-longitudinal growth of nomadic Turkana pastoralists	Turkana County	1981–1983	the data are seasonal, but the author never makes a distinction in outcomes by season	height, age, weight, and skinfolds were measured but not put into a nutritional outcome (except in line graphs)

Stigma as a barrier to treatment for child acute malnutrition in Marsabit County, Kenya	Marsabit County	June, 2013	no	MUAC for moderate acute malnutrition: 122, 120–124 mm; normal: 135, 129–141 mm; severe acute malnutrition: 113, 111–114 mm
Effects of drought on child health in Marsabit district, Northern Kenya	Marsabit County	2009–2013	Jun–Sep (average)	−1.04 MUAC z-score
Chronic undernutrition and traditional weaning foods are associated with fat stores in Ariaal infants of Northern Kenya	Marsabit County	Nov 2008–Jan 2009	Nov–Jan (average)	HAZ −0.82 +/- 1.4
Malnutrition and childhood disability in Turkana, Kenya: Results from a case-control study	Turkana County	Jul and Aug 2013	no	mean //child with disabilities: MUAC for height −1.4 ; WAZ −2.1; HAZ −1.4; BMI for age −1.6; WHZ −1.5 // sibling control: MUAC for height −1.0; WAZ −1.5; HAZ −1.0; BMI for age −1.3; WHZ −1.2 *only WHZ is not significant*
Food insecurity and not dietary diversity is a predictor of nutrition status in children within semiarid agro-ecological zones in eastern Kenya	Machakos and Makueni Counties	May–Jun 2012	season described as season of "plenty"	mean HAZ z-score −1.51 (mean WAZ z-score −0.78 mean (SE) WHZ z-score 0.02 stunting 33.8% underweight 11.6% wasting 2.5%
Animal milk sustains micronutrient nutrition and child anthropometry among pastoralists in Samburu, Kenya.	Samburu County	2000, 2005, 2010, 2012 Jun 2000–Jun 2001; Jul–Aug 2005; Jul–Aug 2010	no, limitation	0–2 years (n = 33); HAZ −1.49 (; WAZ −1.32 ; BMI −0.57 ; stunting 41.9%; underweight 34.4%; low BMI 10.0% 3–5 years (n = 42); HAZ −1.26 ; WAZ −1.31); BMI −0.75 ; stunting 22.0%; underweight 14.6%; low BMI 7.3%
Child malnutrition and climate in sub-Saharan Africa: An analysis of recent trends in Kenya	Kenya	2008	no	Northeastern agropastoral zone , HAZ: −1.32; northeastern pastoral zone , HAZ −1.78; northern pastoral zone , HAZ: −1.48; northwestern pastoral zone , HAZ: −2.13

Brief communication: Chronic undernutrition is associated with higher mucosal antibody levels among Ariaal infants of Northern Kenya	Marsabit County	Nov 2008 and Jan 2009	no	Avg. age: 10.6 //HAZ −0.82 % stunted (< −2.0 HAZ) 17.6% WAZ −0.97 % underweight (< −2.0 WAZ) 15.1% infant average triceps skinfold (mm) 9.4 Infant MUAC (cm) 14.2
Evaluating the level of adherence to Ministry of Health guidelines in the management of severe acute malnutrition at Garissa Provincial General hospital, Garissa, Kenya	Garissa County	Jul–Oct 2012	no	*Can't really report because the population is only children with severe acute malnutrition*
Spatial variability of malnutrition and predictions based on climate change and other causal factors: A case study of North Rift ASAL counties of Kenya	North Rift arid and semi-arid lands	2014	no	****NOTE: estimating from a graph, not actually given exact numbers//Turkana: underweight: 33%, wasted: 22%, stunted: 23%*
Pastoral sedentarization and its effects on children's diet, health, and growth among Rendille of Northern Kenya	Marsabit County	Every 2 months from Sep 1994 to Jun 1997	yes, but aggregated: normal vs. heavy rainfall/ drought	*only reported in graph*
Trends and determinants of undernutrition among young Kenyan children: Kenya Demographic and Health Survey; 1993, 1998, 2003 and 2008–2009	Kenya	1993, 1998, 2003, 2008–2009	no	stunting: 39.9% in 1993 to 35.3% in 2008–2009, underweight: 18.7% in 1993 to 16.0% in 2008–2009

Diarrhoea and malnutrition among children in a Kenya district: A correlation study	Ijara District	2009	yes	*only reported in graph*
Nutrition sensitive multi-sectoral planning: experiences on Link Nutrition Causal Analysis Kenya	West Pokot County	Mar–July 2015	yes	stunting: 45.9%

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