WORKING PAPER

working paper **number 186**
october, 2019

ISSN 1812-108x

Education, cooperative conflicts and child malnutrition—a gender-sensitive analysis of the determinants of wasting in Sudan

Lea Smidt, International Policy Centre for Inclusive Growth (IPC-IG)

15 years
international policy centre for inclusive growth

International Policy Centre for Inclusive Growth (IPC-IG)

SBS, Quadra 1, Bloco J, Ed. BNDES, 13º andar
70076-900 Brasília, DF - Brazil
Telephone: +55 61 2105 5000

ipc@ipc-undp.org ▪ www.ipcig.org

The International Policy Centre for Inclusive Growth is jointly supported by the United Nations Development Programme and the Government of Brazil.

Working Papers are available online at www.ipcig.org and subscriptions can be requested by email to ipc@ipc-undp.org.

Print ISSN: 1812-108X

EDUCATION, COOPERATIVE CONFLICTS AND CHILD MALNUTRITION—A GENDER-SENSITIVE ANALYSIS OF THE DETERMINANTS OF WASTING IN SUDAN

Lea Smidt[1]

Sudan has one of the highest wasting rates globally, reflecting endemic child malnutrition. Cross-national research has identified gender inequality as a common predictor for such child health deprivations. At household level, studies support this finding by showing that maternal education improves children's health outcomes. Yet authors disagree on whether education measures a woman's economic situation, her capacity or her status. In addition, mothers' education is examined irrespective of fathers' education; thus, the gender perspective is incomplete. Therefore, this paper investigates how and through which channels parents' respective and relative levels of education affect wasting. The central argument is that a mother's level of education reduces her children's risk of wasting independent of the father and their household's economic situation because education improves the mother's nutritional knowledge and bargaining power. Using a two-stage residual inclusion approach, my findings from a sample of nearly 8,000 Sudanese children corroborate my argument: maternal education decreases the likelihood of wasting via the quality of a child's diet and by increasing the mother's bargaining power, after controlling for household wealth and food security. By contrast, paternal education has no effect on a child's diet or nutritional status. Children of fathers with a university diploma are at an even greater risk of wasting. Mothers' and fathers' relative levels of education do not influence children's nutritional outcomes. These results suggest that interventions should focus on empowering women through capacity-building and material support and by enhancing their legal and perceived autonomy from their husbands to increase their decision-making power.

Keywords: child malnutrition, gender, intra-household bargaining, parental education, Sudan.

1 INTRODUCTION

Gender inequality is a strong predictor for variations in child health deprivation across countries (Branisa, Klasen, and Ziegler 2013; Ekbrand and Halleröd 2018; Marphatia et al. 2016). Household-level studies seem to corroborate cross-national research: they find a link between mothers' education and child health outcomes (Akombi et al. 2017a; Cochrane, Leslie, and O'Hara 1982; Duflo 2012). However, these studies disagree about whether education affects

1. International Policy Centre for Inclusive Growth (IPC-IG).

child health by improving a woman's economic situation/income (Desai and Alva 1998) or her capabilities—i.e. knowledge and rights (Abuya et al. 2011; Frost, Forste, and Haas 2005; Güneş 2015). It is impossible to discern between these differential effects, as studies use education as a proxy for the different concepts they intend to measure—for example, income, knowledge, autonomy or status (Duflo 2012). Importantly, in micro-level research the gender perspective remains incomplete because mothers' education is examined irrespective or independent of fathers' education. Thus, it is unclear whether policies should prioritise one-sided female empowerment or broadly targeted long-term activities transforming socially rooted gender roles and relations. Therefore, this paper investigates how and through which channels parents' respective and relative levels of education affect child health outcomes. The health outcome of interest is wasting—i.e. low weight-for-height—which is an indicator of child malnutrition resulting from rapid weight loss.

The central argument is that mothers' level of education reduces children's risk of wasting independent of the father and the household's economic situation because education improves mothers' nutritional knowledge and bargaining power. I further contend that paternal education has no effect on children's nutritional status because fathers focus on their own needs to reproduce their workforce and comply with their role as the main breadwinner. By contrast, mothers prioritise their children's health, hygiene and nutrition in household resource allocation because they are the primary caregivers. Using a two-stage residual inclusion approach, I examine this claim in a sample of nearly 8,000 Sudanese children aged between 0 and 36 months.

Reducing wasting is of crucial importance for achieving Sustainable Development Goal (SDG) 3.2. on ending preventable child mortality, because malnourished children are at significantly higher risk of death (Fawzi et al. 1997; IFPRI 2014; Marphatia et al. 2016; Mason et al. 2012; Nielsen, Prudhon, and de Radigues 2011). Sudan, a conflict-affected country, has one of the highest wasting rates globally: 15.8 per cent of Sudanese children under the age of 5 were wasted in 2014, compared to the sub-Saharan African average of 10 per cent (CBS Sudan and UNICEF Sudan 2016). Ranking in 139th place out of 160 countries on the United Nations Development Programme (UNDP) Gender Inequality Index in 2017, Sudan is also characterised by strong discrimination against women in the areas of politics, education and health. While the causal pathways found between maternal education and wasting are only valid for Sudan, the underlying theoretical mechanism has implications for other contexts.

Consequently, my contribution to the literature on child poverty and gender is threefold. First, I bridge theoretical arguments on the role of parental education, on the one hand, and gender roles, on the other hand, to better explain variations in child health outcomes. The findings show that education per se might not improve children's well-being, but that investment in mothers' education does. Levelling parents' education, however, does not improve children's health by fostering greater cooperation between parents. Second, my analyses generate evidence on the transmission channels between parental education and wasting. In particular, the results reveal that education reduces children's risk of wasting by increasing mothers' capabilities rather than households' income. By contrast, fathers' education affects household wealth but has no effect on children's nutritional status. Thus, instead of engaging in the arduous and contentious process of transforming societal gender relations, interventions should aim to empower women. Third, I evaluate the impact of other determinants of wasting relative to parental education in Sudan. These results will help policymakers define priority groups and areas for malnutrition interventions in Sudan.

In the following section, I review the literature on the determinants of wasting and the effect of parental education on child health. Next, I outline my hypotheses on the determinants of wasting. The fourth and fifth sections present my methodology and empirical findings. Last, I conclude with implications for theory and policy.

2 LITERATURE REVIEW

Thus far, there has been no study that systematically investigates the determinants of wasting in Sudan in general or the impact of parental education on child malnutrition in particular. However, a systematic review of studies from sub-Saharan Africa concludes that a higher level of maternal and paternal education is the most consistent factor associated with a lower risk of wasting (Akombi et al. 2017a). Findings from other contexts cannot necessarily be generalised to Sudan, because the review also shows that the effect of parental education on malnutrition varies across countries. For example, in Burkina Faso neither maternal nor paternal literacy change the likelihood of wasting (Beiersmann et al. 2013). By contrast, in Nigeria, children of fathers and mothers with secondary and higher education are less likely to be wasted (Akombi et al. 2017b). In Ghana, mothers' exposure to secondary schooling reduces weight-for-height (Frempong and Annim 2017). Likewise, in a cross-national analysis only parents' exposure to more than six years of schooling increases height-for-age in sub-Saharan Africa (Alderman and Headey 2017).[2] The studies suggest that basic education does not necessarily reduce wasting, but that characteristics associated with secondary and higher education do.

While the impact of parental education on child malnutrition has not been examined for Sudan, some studies analyse the link between maternal education and child health outcomes. In Khartoum state, maternal secondary and higher education are associated with correct vaccination status, whereas socio-economic status is not (Ibnouf, Van den Borne, and Maarse 2007). Likewise, mothers' education but not social class (defined by area of residence) is negatively correlated with low birth weight (Elshibly and Schmalisch 2008) and perinatal mortality (Hassan et al. 2009) in newborn samples from two Khartoum hospitals, respectively. However, a study using nationally representative data observes an association between mortality and poverty rather than education (Bashir et al. 2013). Although the studies provide some indication, they have several limitations. The majority use samples from Khartoum or hospital sites; thus, their findings cannot be generalised to the wider Sudanese context. Furthermore, authors focus on mothers' education irrespective of fathers' education or other proxies for intra-household dynamics. These empirical lacunas are not remedied by theory because authors remain silent as to what maternal education measures and why it affects child health.

Overall, the literature reaches no consensus on whether and how parental education affects wasting. The literature lacks theoretical clarification as well as systematic investigation. This paper bridges the gap by developing and empirically testing hypotheses on the relationship between parental education and wasting in Sudan.

3 ARGUMENT AND HYPOTHESES

The central argument is that mothers' level of education reduces children's risk of wasting independent of the father and the household's economic situation because education improves mothers' nutritional knowledge and bargaining power. I further contend that paternal education has no effect on children's nutritional status because fathers focus on their own needs to reproduce their workforce and comply with their role as the main breadwinner. By contrast, mothers prioritise their children's health, hygiene and nutrition in household resource allocation because they are the primary caregivers.

3.1 THE EFFECT OF EDUCATION VIA NUTRITIONAL KNOWLEDGE

The first channel through which maternal education affects wasting is nutritional knowledge. Through schooling, women may have greater access to information on nutrition because they can read newspapers, campaign material and websites. More years of schooling also expose women to more learning on health and nutrition. Sensitisation campaigns may take place in schools.

Mothers' education matters more for children's nutritional status than fathers' education because in traditional societies mothers are the primary caregivers. Consistently, 99 per cent of the caregivers interviewed in my sample are children's mothers. Qualitative accounts from Sudan confirm that women are responsible for rearing children and preparing food in the household (House 1988; Ibnouf 2009). Thus, women have greater leverage than men on infant dietary choices. Moreover, as women grow up with the expectation of being the primary caregivers, they are more receptive than men to nutritional knowledge transmitted through schooling (Mahaffy and Ward 2002).

Reported greater dietary diversity, in turn, reduces wasting by providing more nutrients (Akombi et al. 2017a; Frempong and Annim 2017). If women's education affects wasting via better child feeding practices, I expect that:

H1a: Women's education positively affects the quality of their children's diets

and

H1b: Children who receive a more diverse diet are less likely to suffer from wasting.

3.2 THE EFFECT OF EDUCATION VIA HOUSEHOLD-LEVEL DECISION-MAKING

Besides influencing feeding practices, maternal education affects wasting by increasing mothers' bargaining power in intra-household resource allocation. Women's higher decision-making power benefits their children's health and nutrition (Duflo 2003; Richards 2011; Richards et al. 2013). Resource allocation decisions within households involve bargaining between household members. Yet household members' bargaining power is unequally distributed. It depends on members' (1) breakdown positions; (2) perceived interests; and (3) perceived contributions to household resources.

A person's (1) breakdown position relates to his/her willingness to accept ending the bargain without an agreement and reflects his/her strength or vulnerability. (2) Perceived interests may differ from individuals' 'rational choice' to maximise objective indicators of personal welfare. Perceived interests are ambiguous, socially conditioned and linked to someone's sense of appropriateness, legitimacy and desert. If a person's perceived interest is not maximising his/her objective (but, for instance, the family's) welfare, his/her bargaining power is weaker compared to household members whose perceived and objective interests are congruent. (3) Likewise, if an individual's perceived contributions to household resources are inferior to his/her real contributions, his/her bargaining power is lower (Sen 1990). For example, women support the economic activities of their husbands through unpaid reproductive and care work. While women make a crucial contribution to the household's collective resources by reproducing their husband's workforce (her perceived interest), their perceived contribution is often undervalued, as it has no direct monetary return.

How do breakdown positions and perceptions form? A woman's bargaining position, perceived interests and contribution are associated with her status—i.e. the position that is attributed to her in the household and society (Richards 2011; Smith et al. 2003). Status conditions women's access to resources (Richards 2011; Smith et al. 2003) as well as her capabilities—i.e. the freedom to choose and to act (Sen 1990). While women's status partly depends on Sudanese social norms and institutions, it also interacts with a woman's individual characteristics and those of her household.

Maternal education is one of the most commonly used measures for women's status in micro-level research (Richards 2011). Education indicates that a woman has had greater access to schooling (capabilities) and possesses certain skills (functionings),[3] which translate into more economic and political opportunities as well as better access to societal resources (Branisa et al. 2013; Sen 1990). Opportunities and access associated with schooling help a woman negotiate her role in household-level decision-making because her perceived contribution may be greater. Literacy also increases a woman's exposure to news and literature, contributing to her politicisation. Politicisation potentially alters perceived interests. Finally, education changes a woman's breakdown position because it lowers her opportunity cost for a bargain without agreement. An educated woman has more options outside the household due to access to labour markets, health services and information if no agreement on resource allocation is found or her husband threatens breakdown. This suggests that education can alter mothers' status even in highly gender-unequal societies.

Mothers' increased bargaining power in the household positively affects children's nutritional status because the division of labour inside Sudanese households is gendered. Whereas most women are responsible for rearing children and preparing food, men are expected to be the household's main breadwinner. As a result, mothers are more sensitive to their children's needs than fathers. In addition, gender-related societal norms and expectations affect women's and men's interests in resource allocation (Branisa et al. 2013). While women are more concerned with fulfilling their role as a 'good mother', men are more concerned with ensuring the family income. Thus, women prefer to use household resources to the benefit of their children. Children's success may also be economically important, as their future income may pay their mother's retirement pension. By contrast, men are more inclined to spend household resources to reproduce their own workforce—for instance, by staying healthy through better nutrition and medical treatment.

If better-educated women have greater leverage in intra-household resource allocation decisions to the benefit of their children's nutritional status, I observe that:

H2a: Maternal education has a greater influence on reducing the likelihood of child wasting than paternal education.

To attribute the effect of maternal education to women's bargaining power, I test whether children from households where women take decisions are at lower risk of wasting. For this purpose, I draw on the finding that in female-headed households, mothers have greater leverage over resource allocation (Onyango, Tucker, and Eisemon 1994; Richards et al. 2013). Thus, I expect that:

H2b: Children from female-headed households are less likely to suffer from wasting.

The effect of maternal education could also depend on the level of paternal education. Therefore, it is important to not only control for father's education but to test the effect of parents' relative level of education. For example, decision-making in a household where both parents have the same level may be more collaborative. Alternatively, a mother with primary schooling may have greater bargaining power if her husband has no education, compared to the same woman with a husband with secondary or tertiary education. Therefore, I hypothesise that:

H2c: Children of mothers with the same or a superior level of education than that of the child's father are less likely to suffer from wasting.

3.3 THE EFFECT OF EDUCATION VIA INCOME: SUBSTITUTION OR COMPLEMENTATION?

My argument could be challenged if education is a proxy for household wealth instead of women's increased bargaining power. Women with more education are more likely to come from wealthier families, have greater labour market options and earn higher incomes. Highly educated women with better-paid jobs are also more likely to have better-educated husbands with better-paid jobs. Thus, women's education might measure the availability of household resources for children instead of higher maternal decision-making power and nutritional knowledge.

To test whether parental education and income are complementary or (perfect or partial) substitutes, I hypothesise that:

H3a: Children from wealthier households are at lower risk of wasting.

H3b: Maternal education has no effect on wasting if household income is accounted for.

4 METHODOLOGY

4.1 DATA

My data come from the fifth round of the Multiple Indicator Cluster Survey (MICS5) conducted in 2014 (CBS Sudan and UNICEF Sudan 2016). MICS5 provides the most recent, publicly available and representative survey data from Sudan. It covers 97,049 individuals from 16,801 households. Data collection took place from 10 September to 30 October 2014 using pencil-and-paper-assisted interviewing (PAPI). The Sudanese MICS includes three separate questionnaires, which are administered at household-, women- and child-level.

The survey used a two-stage, stratified cluster sampling approach to select 18,000 households from 720 enumeration areas (EAs) located in all 18 states, stratified by rural and urban areas. The 2008 census data constituted the sampling frame. The EA is the primary sampling unit (PSU). In the first stage, EAs were sampled from urban and rural strata in each state, proportional to the size of the stratum. Next, 25 households were systematically selected in each EA.

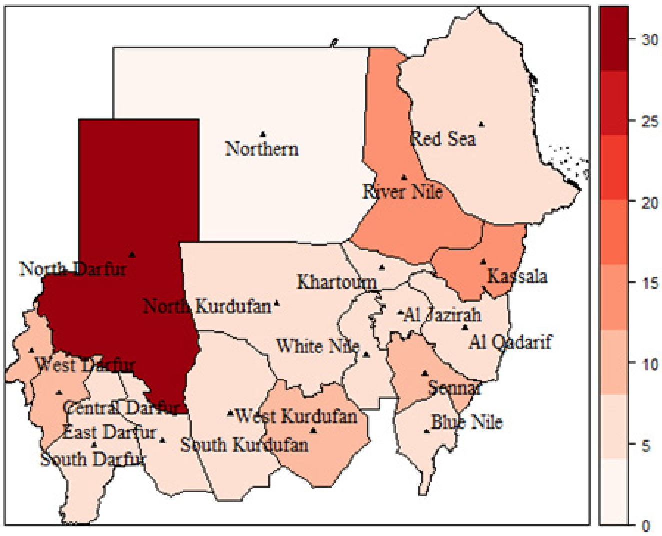
Of the 18,000 sampled households, 16,807 responded to the questionnaire. This represents a response rate of 98.0 per cent, ranging from 93.4 per cent in West Kordofan to 99.3 per cent in South Darfur. Within these households, fieldworkers identified 20,327 women between 15 and 49 years, of which 18,302 (90.0 per cent) responded to the questionnaire. The response rate for the questionnaire addressing caregivers of children under 5 was 95.5 per cent, resulting in information on 14,081 children. After merging and dropping missing observations on the outcome variable, the final sample contains 7,490 children.

4.2 OUTCOME VARIABLE

The outcome variable in this research design is children's likelihood of wasting. According to the World Health Organization (WHO), a child suffers from wasting if its weight-for-height measure is below the WHO standard for his/her age. Wasting is a manifestation of current or acute malnutrition after severe weight loss. To generate an indicator for wasting, I use children's weight-for-height measures provided by the MICS. These measures have already been z-standardised by subtracting the mean weight-for-height in a global WHO sample of healthy children from the observed weight-for-height values and then dividing through the standard deviation (SD) of the WHO sample. Based on the z-scores, I compute the indicator for wasting. It is binary, taking the value of 1 if the child's weight-for-height is below 2 SD of the WHO mean (mean = 0, and SD = 1 for the standardised scale). This corresponds to the internationally agreed definitions for moderate (below 2 SD) and severe malnutrition (below 3 SD). The binary measure is preferred to the continuous z-scores because it excludes other forms of malnutrition associated with overweight.

Wasting prevalence varies across children, households, EAs and states. Figure 1 shows considerable variation in wasting rates across states from nearly a third (31 per cent) in North Darfur to 12.4 per cent in Northern. Yet the intra-class correlation coefficient indicates that only 1.5 per cent of the observed heterogeneity is related to state-level determinants. Local-level determinants in the EA explain 5.5 per cent of the variation in the likelihood of wasting. Thus, most variation in wasting is explained by household- or child-level variables. Variation across states is likely explained by the spatial distribution of variables at household or child level.

FIGURE 1
Wasting rates (%) among children aged 0–3 years by state in 2014



Source: CBS Sudan and UNICEF Sudan (2016).

4.3 MAIN EXPLANATORY VARIABLES

The main independent variables for testing my hypotheses are mothers' and fathers' highest completed level of education, mothers' nutritional knowledge, the sex of the head of the household, parents' joint level of education, and household-level asset wealth. Parental education is a categorical indicator for the highest level of schooling attained by the mother and the father, respectively. Education levels are no schooling, primary schooling, secondary schooling and higher education. They are introduced as dummy variables, leaving out no schooling as a reference category. An additional dummy for fathers' absence from the household is introduced in the equation.

As in my sample, most caregivers are children's mothers (98.5 per cent). I interpret caregivers' self-reported feeding practices as indicators for mothers' nutritional knowledge. Specifically, mothers' nutritional knowledge is reflected in the diversity of aliments provided to a child. For conceptualisation, I draw on the indicator for measuring child dietary diversity agreed on by several donors, including UNICEF (WHO et al. 2008). The indicator is operationalised as a composite index of several survey items asking caregivers which foods were consumed by the child during the previous day or night. Foods are aggregated into seven groups of nutrients: (1) grains, roots and tubers; (2) legumes and nuts; (3) dairy products; (4) flesh foods; (5) eggs; (6) vitamin-A-rich fruits and vegetables; and (7) other fruits and vegetables. The dietary diversity score used in the analysis adds up the number of food groups from which a child consumed and ranges from 0 to 7. The score has previously been used to examine the effect of dietary diversity on wasting in Ghana (Frempong and Annim 2017).

Furthermore, mothers with greater nutritional knowledge are more likely to exclusively breastfeed their children up to the age of 7 months as recommended by the WHO. This reduces dietary diversity. To capture the net effect of mothers' nutritional knowledge through dietary diversity, I control for breastfeeding at the recommended age. As the benefits of breastfeeding are conditional on the child's age, I decide to transform the breastfeeding indicator into a dummy. It takes the value of 1 if a mother reports that the child is breastfed and is below the age of 7 months, and 0 otherwise.

As my data do not include an income, consumption or employment measure, I use the wealth quintile distribution in the sample to control for the effect of economic status. Households are categorised into quintiles based on a composite asset ownership index.

TABLE 1
Main explanatory variables for wasting

Variable	Indicator/item	Expected effect
Parental education	- Mother's highest level of education - Father's highest level of education - Parents have same level of education - Mother has higher level of education than father	- 0 - -
Mothers' nutritional knowledge	Dietary diversity score composed of the foods given to a child in the past 24 hours: (1) grains, roots and tubers; (2) legumes and nuts; (3) flesh foods (meat, fish, poultry and liver/organ meats); (5) eggs; (6) dairy products (milk, yogurt, cheese); (7) Vitamin-A-rich fruits and vegetables; (8) other fruits and vegetables.	-
	Breastfeeding at recommended age (below the age of 7 months)	-
Female decision-making autonomy	Head of the household is female (1 = Yes; 0 = No)	-
Household wealth	Composite index of asset ownership by a household (poorest, second, third, fourth, richest quintile)	-

4.4 CONTROL VARIABLES

Beyond the variables related to parents' education, knowledge, bargaining power and income, several socio-demographic characteristics of the child and the household as well as the child's health endowments may affect the risk of wasting. I control for these variables in my analysis. At individual child level, I introduce dummy variables for sex, orphanage status and being sick with diarrhoea in the past two months to the equation. At household level, I control for a household's geographic location, food shortages, size (number of members) and access to improved sanitation and clean water.

TABLE 2
Control variables

Variable	Indicator/item	Expected effect
Socio-demographic indicators	- Female - Orphan	- +
Household characteristics	- Food insecurity (shortage) - Size of the household - Geographic area (1 = rural; 0 = urban) - Use of improved drinking water[4] - Use of improved sanitation[5]	- + + - -
Health	Child ill with diarrhoea during last 2 months	+

4.5 MODEL SPECIFICATION

To examine how and through which channels parental education influences the risk of wasting, I estimate a logistic two-stage residual inclusion regression. The specification is appropriate for binary outcomes because the dependent variable is binomially distributed. I use a two-stage estimation approach to test the effect of maternal education on wasting via dietary diversity (hypotheses 1a and 1b). Thus, the results from the first-stage regression provide evidence for or against hypothesis 1a.

Using the two-stage model requires instrumental variables to deal with endogeneity. The endogenous regressor in my design is dietary diversity. The quality of a child's diet depends on caregivers' nutritional knowledge after controlling for their economic capacity to provide food (food shortages and asset wealth). However, a caregiver's dietary choices also depend on the child's nutritional status, as she responds to wasting by improving her child's diet. In addition, mothers of wasted children may acquire greater knowledge on nutrition. They are also more likely to be targeted by any sensitisation campaigns and capacity-building measures. Thus, the assumed direction of causality is two-way: mothers' knowledge of nutrition reduces the risk of wasting, but wasting also increases mothers' awareness of nutrition and leads to focusing available nutritional resources on the wasted child. This simultaneous correlation results in endogeneity—i.e. a correlation between dietary diversity and the residuals.

Moreover, I account for systematic heterogeneity of wasting rates across states using fixed effects.[6] To correct for correlated observations within EAs, I estimate cluster-robust standard errors.[7] Unfortunately, I cannot explain spatial variation by including contextual variables—for example, casualties from armed conflict—in a multilevel model. The number of observations within EAs and the number of states are too small to consistently estimate random intercepts (Sommet and Morselli 2017).[8]

As my dependent variable is dichotomous, I use a two-stage residual inclusion (2SRI) instead of a two-stage least square (2SLS) regression. It is least biased for non-linear regression settings (Koladjo, Escolano, and Tubert-Bitter 2018; Terza 2018; Terza, Basu, and Rathouz 2008). The second-stage model is specified as

$$y_{ips} = \mathrm{F}(\beta_0 + \beta_1 x_{ips} + \beta_2 X_{ips} + \beta_3 u_{ips} + \mu_s + \epsilon_{ip})$$

where y_{ips} represents the vector of outcomes x_{ips} , the vector of values for the endogenous regressor x_{ips}, and a matrix of individual- and household-level exogenous covariates for individual i in PSU p in state s, respectively. u_{ips} is a vector of unobserved covariates estimated in the first-stage regression μ_s represents the state fixed effect, and ϵ_{ip} the error term clustered at PSU level $F(.)$ constitutes the logit link function $\beta_{0,1,2,3}$ are the parameters estimated by the 2SRI model.

If u_{ips} were omitted from the model, the parameter estimates would be biased. u_{ips} represents caregivers' adjustment in child feeding practices in response to wasting. The problem is that u_{ips} is unobserved. The 2SRI method resolves this problem by estimating a first-stage regression of the endogenous regressor on the exogenous and the instrumental variables. If the identifying assumptions for the instruments hold, the residuals from this first-stage regression constitute , which is the endogenous part of the variation in dietary diversity. The specification of the first-stage regression is a linear regression defined as

$$\widehat{x_{ips}} = \alpha_0 + \alpha_1 Z_{ips} + \alpha\ _2 X_{ips} + \alpha_s + u_{ips}$$

where $\widehat{x_{ips}}$ is the endogenous regressor of the second-stage regression, and Z_{ips} the matrix of instrumental variables. α_0, α_1 and α_2 are the parameter estimates. α_s represents the state fixed effect u_{ips} are the non-clustered error terms representing variation in $\widehat{x_{ips}}$ due to wasting.

The instrumental variables in Z_{ips} are the age of a child in months and whether the child's household owns livestock and has agricultural land. Including the instruments eliminates endogenous variation in dietary diversity by estimating the 'true' values of x_{ips} independent of wasting if four identifying assumptions hold. First, the instruments are 'randomly assigned' (independence assumption). Age and households' ownership of animals and land fulfil this condition because they are not predetermined by wasting or the exogenous regressors. Second, the instruments are only indirectly correlated with the outcome through their effect on the endogenous regressor (exclusion restriction). Age only affects wasting indirectly, as mothers increase dietary diversity with age. Likewise, wasting does not depend on livestock or land ownership directly but through children's diet, especially if the family's income is controlled for. The third and fourth assumptions are that the effect of the instruments on the endogenous regressor is strong (relevance assumption) and unidirectional (monotonicity assumption). Age is strictly positively correlated with dietary diversity because older children can eat more foods than younger children. Likewise, households with animals and agricultural land can provide a richer diet to their children than those without their own food production (Frempong and Annim 2017).

5 DISCUSSION OF FINDINGS

5.1 RESULTS FROM THE REGRESSION MODELS

5.1.1 Mothers' education reduces the likelihood of wasting via dietary knowledge

The main results from the 2SRI models are shown in Table 3. Column 1 shows the results of the second-stage regression of wasting on all independent variables except household wealth. The second column of the table presents the results of the first-stage regression of dietary diversity on the instruments and the exogenous regressors of the second-stage model in column 1. Columns 3 and 4 present the results of the same model but include household asset wealth.

The results shown in Table 3 confirm my hypotheses 1a and 1b: mother's education decreases the risk of wasting by increasing dietary diversity. The first-stage regression results in column 2 show that children of mothers with higher levels of education consume more types of food than their counterparts with mothers without formal schooling (hypothesis 1a). The effect of maternal education is independent of food security at household level. Therefore, the effect of dietary diversity is unlikely to be a proxy for the household's economic situation or market access but, rather, mothers' greater nutritional knowledge. Greater dietary diversity, in turn, decreases the risk of wasting after the inclusion of the first-stage residuals at the second stage (hypothesis 1b).[9]

Moreover, the second indicator for mothers' nutritional knowledge—breastfeeding at the appropriate age—reduces the risk of wasting. In the first stage this variable has a negative effect because children under the age of 6 months are mostly exclusively breastfed. After this age, babies can be fed solid food, and diversity increases (see coefficient estimate of the instrument age).

5.1.2 The effect of mothers' influence on household resource allocation decisions

Second, a mother's education has a direct negative effect on the likelihood of wasting (hypotheses 2a). Specifically, higher and secondary education decrease the likelihood of wasting compared to no schooling. Although the coefficient for primary education does not pass the significance threshold, it is also negative. The results align with previous studies from sub-Saharan Africa, which find a negative relationship between maternal education above the basic level and wasting, but no association between literacy and wasting (Akombi et al. 2017b; Alderman and Headey 2017; Beiersmann et al. 2013; Frempong and Annim 2017).

TABLE 3
Instrumental variable regression results for wasting (children 0–36 months)

	(1) Second stage	(2) First stage	(3) Second stage	(4) First stage
(Intercept)	-0.35 (0.26)	1.12 (0.11)***	-0.38 (0.27)	0.92 (0.11)***
Nutrition				
Food diversity	-0.23 (0.08)***		-0.23 (0.08)***	
Residuals stage 1	0.24 (0.08)***		0.24 (0.09)***	
Food shortage, HH	0.00 (0.08)	-0.19 (0.04)***	-0.00 (0.08)	-0.15 (0.04)***
Breastfeeding < 7 months	-0.91 (0.22)***	-1.59 (0.06)***	-0.91 (0.22)***	-1.59 (0.05)***
Mother's education (ref.: none)				
Primary	-0.09 (0.09)	0.19 (0.04)***	-0.09 (0.08)	0.14 (0.04)***
Secondary	-0.22 (0.13)*	0.57 (0.06)***	-0.19 (0.12)	0.42 (0.06)***
Higher	-0.48 (0.19)**	0.63 (0.08)***	-0.40 (0.20)**	0.37 (0.09)***
Father's education (ref.: none)				
Primary	0.04 (0.10)	-0.00 (0.04)	0.04 (0.09)	-0.03 (0.04)
Secondary	0.03 (0.12)	0.11 (0.06)*	0.04 (0.12)	0.03 (0.06)
Higher	0.33 (0.17)**	0.26 (0.09)***	0.37 (0.18)**	0.13 (0.09)
Father absent	0.09 (0.15)	0.13 (0.07)*	0.09 (0.15)	0.11 (0.07)
Female head of household	-0.26 (0.15)*	-0.27 (0.08)***	-0.25 (0.16)	-0.27 (0.08)***
Child's health				
Diarrhoea	0.18 (0.07)**	0.06 (0.04)*	0.18 (0.07)**	0.07 (0.04)*

→

Socio-demographics, child				
Female	-0.03 (0.06)	-0.03 (0.03)	-0.03 (0.06)	-0.03 (0.03)
Orphan	-0.17 (0.32)	0.17 (0.14)	-0.16 (0.32)	0.17 (0.14)
Socio-demographics, HH				
Rural area	0.17 (0.10)*	-0.42 (0.04)***	0.15 (0.10)	-0.26 (0.05)***
Improved water source	-0.14 (0.10)	0.07 (0.05)	-0.16 (0.11)	0.11 (0.05)**
Improved sanitation	-0.03 (0.09)	0.28 (0.04)***	0.01 (0.11)	0.11 (0.05)**
Household size	-0.00 (0.01)	0.01 (0.01)	-0.00 (0.01)	-0.00 (0.01)
Income quintile (ref.: poorest)				
Second			0.08 (0.10)	0.20 (0.05)***
Middle			-0.00 (0.14)	0.36 (0.06)***
Fourth			0.01 (0.18)	0.64 (0.08)***
Richest			-0.23 (0.22)	1.06 (0.10)***
Instruments				
HH has livestock		0.08 (0.04)**		0.14 (0.04)***
HH owns agricultural land		0.14 (0.04)***		0.16 (0.04)***
Age (months)		0.05 (0.00)***		0.05 (0.00)***
State FE (ref.: North Darfur)				
Northern	-0.50 (0.28)*	1.58 (0.11)***	-0.45 (0.29)	1.18 (0.12)***
River Nile	0.06 (0.20)	1.06 (0.11)***	0.11 (0.22)	0.70 (0.11)***
Red Sea	-0.74 (0.23)***	0.51 (0.12)***	-0.73 (0.24)***	0.36 (0.12)***
Kassala	-0.41 (0.20)**	0.03 (0.10)	-0.40 (0.21)*	-0.10 (0.10)
Gadarif	-0.60 (0.20)***	0.87 (0.09)***	-0.61 (0.21)***	0.73 (0.10)***
Khartoum	-0.35 (0.23)	0.85 (0.10)***	-0.29 (0.23)	0.56 (0.11)***
Gezira	-0.57 (0.20)***	0.81 (0.10)***	-0.53 (0.21)**	0.41 (0.11)***
White Nile	-0.58 (0.20)***	0.84 (0.10)***	-0.58 (0.21)***	0.62 (0.10)***
Sinnar	-0.53 (0.19)***	0.79 (0.10)***	-0.51 (0.22)**	0.50 (0.10)***
Blue Nile	-0.79 (0.21)***	1.23 (0.09)***	-0.79 (0.21)***	1.01 (0.10)***
North Kordofan	-0.81 (0.18)***	0.37 (0.10)***	-0.82 (0.19)***	0.33 (0.10)***
South Kordofan	-0.68 (0.17)***	0.74 (0.09)***	-0.70 (0.19)***	0.65 (0.09)***
West Kordofan	-0.55 (0.22)**	1.02 (0.10)***	-0.57 (0.22)***	1.02 (0.10)***
West Darfur	-0.62 (0.19)***	0.27 (0.10)***	-0.62 (0.19)***	0.23 (0.10)**
South Darfur	-0.87 (0.21)***	0.37 (0.09)***	-0.87 (0.22)***	0.36 (0.09)***
Central Darfur	-0.85 (0.19)***	0.10 (0.10)	-0.86 (0.20)***	0.02 (0.10)
East Darfur	-0.92 (0.21)***	0.32 (0.09)***	-0.92 (0.21)***	0.31 (0.09)***
AIC	6,387.48		6,386.66	
BIC	6,641.49		6,668.13	
Log likelihood	-3,156.74		-3,152.33	
Deviance	6,313.48		6,304.66	
Num. obs.	7,082	8,068	7,082	8,068
R^2		0.42		0.43
Adj. R^2		0.42		0.43
RMSE		1.45		1.44

Note: Cluster-robust bootstrap standard errors (500 draws with replacement) are reported in parenthesis. Clustering is at the enumeration level (primary sampling unit); ***p < 0.01, **p < 0.05, *p < 0.1.

Strikingly, for fathers' education the effect seems to point in the opposite direction. Children of fathers who have obtained higher education are at greater risk of wasting than those whose fathers did not go to school. While the coefficients for secondary and primary schooling are not significant, they are also positive. This finding suggests that while mothers' education benefits their children, fathers' education increases their vulnerability to malnutrition. The finding that paternal education increases children's risk of wasting seems puzzling at first glance. However, if education is associated with a person's status, the result confirms my argument that only mothers' increased bargaining power in the household benefits her children. By contrast, fathers with more education—hence higher status and bargaining power—seem to make poorer decisions for their children. This may be linked to the fact that better-educated fathers are more dominant, which decreases mothers' relative decision-making power.

There is no evidence that the absence of the father from the household increases the risk of wasting.[10] Conversely, fathers' absence positively affects the quality of a child's diet, which reduces the risk of wasting. This result challenges the findings of qualitative studies that mothers' marital status and parents' cohabitation have a positive effect on mothers' treatment-seeking behaviour, which in turn should have a positive effect on children's health outcomes (Richards 2011).

Correspondingly, children from female-headed households are significantly less likely to be wasted (hypothesis 2b). This finding corroborates my argument that increased mothers' decision-making power in the household alters household resource allocation to the benefit of children's health. In female-headed households, the father is likely to be absent, turning the mother into the main breadwinner. Thus, mothers have greater control over resources. The joint negative effects of maternal education and female-headed households as well as the positive effect of fathers' absence corroborate my expectation that mothers' higher bargaining power (due to raised status or substitution of the male breadwinner) decreases children's risk of wasting.

It should be noted that the first-stage regression results also provide valuable information. Specifically, female-headed households are less likely to provide a diverse diet to their children on average. Thus, while women heads of households decrease the likelihood of wasting directly due to increased control over household resources, they may be more constrained in terms of money and food production in providing a high-quality diet to their children. Low dietary diversity in turn increases the risk of wasting. In the following subsection (5.4.), I calculate the substantive effect of female-headed households based on the opposing coefficient estimates from the first- and second-stage regressions.

Finally, there is no evidence in support of my hypothesis 2c that children of mothers with the same or a superior level of education than that of the child's father are less likely to suffer from wasting. In Table 4, I substitute the factor variables for maternal and paternal level of education by a dummy variable. Dietary diversity increases if the child's mother has a higher level of education than the father. The direct effect of parents' relative level of education is negative but not different from zero. There are three explanations for this null finding: first, women's absolute level of education matters, but household dynamics do not necessarily improve in women's favour if they have a high level of education in relative terms. Second, the observed positive effect of paternal education in models 1 and 3 in Table 3 counteracts the negative effect of maternal education on children's risk of wasting. A third explanation is statistical rather than theoretical. Due to the recoding of the parental education variables, children whose fathers are absent from the household are dropped from the sample. This results in a reduction of the sample size and makes it more difficult to detect statistically significant effects.

TABLE 4
Results of instrumental variable regression of wasting on parents' joint level of education

	(1) Instrumental variable regression	(2) First stage	(3) Instrumental variable regression	(4) First stage
(Intercept)	-0.42 (0.25)*	0.85 (0.11)***	-0.44 (0.29)	1.09 (0.12)***
Nutrition				
Food diversity	-0.22 (0.09)**		-0.18 (0.10)*	
Residuals stage 1	0.24 (0.09)***		0.20 (0.10)**	
Food shortage, HH	0.00 (0.07)	-0.15 (0.04)***	0.03 (0.08)	-0.16 (0.04)***
Breastfeeding	-0.90 (0.23)***	-1.59 (0.05)***	-0.80 (0.24)***	-1.60 (0.06)***
Parents' joint educational level				
Same level	-0.06 (0.05)	0.19 (0.03)***		
Mother's level higher			-0.12 (0.10)	0.09 (0.05)*
Child's health				
Diarrhoea	0.18 (0.07)**	0.06 (0.04)*	0.18 (0.08)**	0.05 (0.04)
Socio-demographics, child				
Female	-0.04 (0.06)	-0.03 (0.03)	0.02 (0.06)	-0.01 (0.03)
Orphan	-0.22 (0.32)	0.18 (0.14)	-0.35 (1.10)	0.47 (0.46)
Socio-demographics, HH				
Rural area	0.17 (0.10)*	-0.26 (0.05)***	0.15 (0.11)	-0.27 (0.05)***
Improved water source	-0.15 (0.10)	0.10 (0.05)**	-0.16 (0.11)	0.13 (0.05)**
Improved sanitation	0.01 (0.11)	0.11 (0.05)**	0.04 (0.12)	0.12 (0.05)**
Household size	-0.00 (0.01)	-0.00 (0.01)	-0.01 (0.01)	-0.01 (0.01)**
Income quintile (ref.: poorest)				
Second	0.08 (0.10)	0.20 (0.05)***	0.05 (0.10)	0.21 (0.05)***
Middle	0.02 (0.14)	0.36 (0.06)***	-0.10 (0.14)	0.42 (0.07)***
Fourth	0.04 (0.18)	0.65 (0.08)***	-0.12 (0.18)	0.78 (0.08)***
Richest	-0.20 (0.23)	1.07 (0.10)***	-0.38 (0.24)	1.28 (0.10)***
Instruments				
HH has livestock		0.16 (0.04)***		0.14 (0.04)***
HH owns agricultural land		0.17 (0.04)***		0.17 (0.04)***
Age (months)		0.05 (0.00)***		0.05 (0.00)***
State FE (ref.: North Darfur)				
Northern	-0.53 (0.29)*	1.18 (0.12)***	-0.50 (0.31)	1.16 (0.13)***
River Nile	0.06 (0.21)	0.71 (0.11)***	0.04 (0.22)	0.69 (0.12)***
Red Sea	-0.68 (0.24)***	0.40 (0.12)***	-0.77 (0.25)***	0.31 (0.13)**
Kassala	-0.40 (0.20)**	-0.08 (0.10)	-0.41 (0.21)**	-0.27 (0.11)**
Gadarif	-0.62 (0.19)***	0.75 (0.09)***	-0.67 (0.21)***	0.64 (0.10)***
Khartoum	-0.32 (0.22)	0.56 (0.11)***	-0.36 (0.25)	0.53 (0.11)***
Gezira	-0.59 (0.21)***	0.41 (0.10)***	-0.51 (0.23)**	0.39 (0.12)***

→

White Nile	-0.59 (0.19)***	0.63 (0.10)***	-0.66 (0.21)***	0.57 (0.11)***
Sinnar	-0.52 (0.21)**	0.50 (0.10)***	-0.53 (0.20)***	0.43 (0.11)***
Blue Nile	-0.83 (0.21)***	1.02 (0.09)***	-0.81 (0.21)***	0.94 (0.10)***
North Kordofan	-0.83 (0.19)***	0.34 (0.10)***	-0.87 (0.19)***	0.28 (0.10)***
South Kordofan	-0.67 (0.19)***	0.66 (0.09)***	-0.84 (0.19)***	0.61 (0.10)***
West Kordofan	-0.58 (0.23)**	1.02 (0.10)***	-0.59 (0.24)**	1.01 (0.11)***
West Darfur	-0.66 (0.19)***	0.23 (0.09)**	-0.59 (0.21)***	0.20 (0.11)*
South Darfur	-0.86 (0.20)***	0.36 (0.09)***	-0.98 (0.22)***	0.32 (0.10)***
Central Darfur	-0.91 (0.18)***	0.03 (0.10)	-0.89 (0.22)***	0.00 (0.11)
East Darfur	-0.92 (0.20)***	0.32 (0.09)***	-1.03 (0.21)***	0.30 (0.10)***
AIC	6,445.66		5,660.91	
BIC	6,679.36		5,890.06	
Log likelihood	-3,188.83		-2,796.45	
Deviance	6,377.66		5,592.91	
Num. obs.	7,140	8,133	6,246	7,109
R^2		0.43		0.43
Adj. R^2		0.43		0.42
RMSE		1.44		1.45

Note: Cluster-robust bootstrap standard errors (500 draws with replacement) are reported in parenthesis. Clustering is at the enumeration level (primary sampling unit); ***p < 0.01, **p < 0.05, *p < 0.1.

5.1.3 The effect of education is only partly substituted by the wealth effect

In columns 3 and 4 of Table 3, household-level asset wealth is added to the model to test whether income substitutes the effect of education. Clearly, poorer households are less capable of providing a diverse diet to their children (column 4). While this slightly reduces the size of the effect of maternal education on dietary diversity in the first stage, mothers' education still has a highly significant and positive impact. Interestingly, however, when adding household-level wealth to the 2SRI model, the positive effect of paternal education on dietary quality in the first stage disappears. This suggests that fathers' education is completely substituted by income, while mothers' education and income are nearly complementary. The finding corroborates my argument that the effect of maternal education on wasting via dietary diversity reflects the impact of mothers' nutritional knowledge independent of the household's economic situation. For fathers who are less involved in food preparation and caregiving, the effect of education on a child's diet seems to be a proxy for household resources to provide adequate nutrition.

The second-stage regression in the wealth-augmented model in column 3 further shows that income has no direct effect on the risk of wasting. There may be a statistical explanation for this finding, as my model includes other covariates that may be highly correlated with household level wealth, such as access to improved sanitation and clean water. Yet the theoretical implication of the null finding is that parental education is not a proxy for income. In addition, the coefficients for maternal levels of education only decrease minimally in size, and the coefficient for higher education is still highly significant.

The control covariates in the models inform about other determinants of wasting. As expected, children who suffered from diarrhoea within the two months previous to the survey are more likely to suffer from wasting. The socio-demographic control variables have no effect on wasting. Girls are at equal risk of wasting as boys. Orphans are not at any higher risk of wasting. Neither access to improved sanitation and an improved source of water nor the size of the household systematically affect the likelihood of wasting.

Finally, heterogeneity in wasting across space is systematic. The increase in standard errors when recalculated from the cluster-robust variance covariance matrix points to clustering within PSUs. The coefficient estimates for the state dummies are all significant except for Northern, River Nile and Khartoum state. As all the coefficient estimates are negative, the risk of wasting is highest for children from North Darfur, based on unobserved state-level factors. This finding is in line with food insecurity alerts for Sudan. North Darfur has been one of the states constantly under stress or in crisis (Famine Early Warning System 2014). It is also the state with the highest number of casualties from armed conflict (Melander, Pettersson, and Themnér 2016; Sundberg and Melander 2013).

5.1.4 Robustness checks

To check the robustness of my results to alternative model specifications, I run the same model as in columns 3 and 4 of Table 3 but using other outcome measures. I also replace the dietary diversity measure by household-level indicators in a simple fixed-effects model. The results of these robustness tests are included in the annex.

First, Table 8.2 presents the results from a logistic regression without instrumenting for dietary diversity. As expected, dietary diversity has no effect on wasting. The coefficient estimates for maternal education remain significant and increase in size, as they also capture mothers' nutritional knowledge in the one-stage design.

Second, I compute a model using the continuous weight-for-height z-scores as a dependent variable. This measure is different from wasting, as very high z-scores reflect overweight (2.8 per cent of children), which is not considered in the wasting analysis. I estimate a linear 2SLS regression instead of a logistic 2SRI model. For most predictors the direction and significance level of the coefficients is similar to the estimates in Table 3. Yet the coefficient for dietary diversity is small and insignificant. Likewise, the coefficient for female head of the household becomes insignificant but points in a positive direction as expected. This suggests that very high and very low weight-for-height z-scores are associated with a lower-quality diet and with the household head being male—i.e. a curvilinear relationship.

Third, I substitute the outcome measure for wasting by a binary indicator for severe wasting. This indicator takes the value of 1 if a child's weight-for-height z-score is below 3SD from the mean. The results from the main model in Table 3 are robust when changing the cut-off point for the outcome. Thus, the likelihood of a child being affected by severe wasting is predicted by similar variables to those for moderate wasting (-2 SD). Children from female-headed households are even at lower risk of severe wasting.

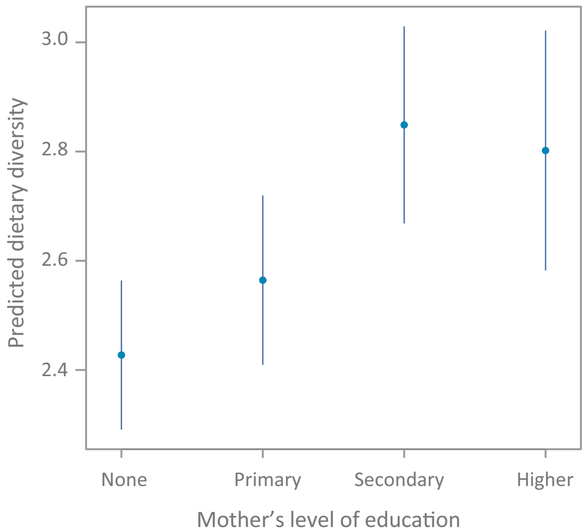
Fourth, I substitute the child-level dietary diversity score by a household-level dietary diversity score. The results are shown in Table 10 in Annex 8.3. Based on households' reported consumption of food items, I recalculate the UNICEF measure for child dietary diversity (WHO et al. 2008) and generate another similar measure suggested by the United

Nations Food and Agriculture Organization (FAO) for the household level (Kennedy, Ballard, and Dop 2011). I assume that these scores are not endogenous to wasting because they are related to household-level factors—such as subsistence farming—rather than to the child. Thus, I estimate a single-stage logistic fixed-effects regression. As dietary diversity at household level is likely to be correlated with most of the socio-economic household-level variables, I include the control variables in two steps. Columns 1 and 3 of Table 10, respectively, show that the number of aliments consumed by a household decreases the risk of wasting. Yet, when adding the socio-demographic control variables in columns 2 and 4, the coefficients of the dietary diversity measures are no longer significant. This suggests that household-level factors other than dietary diversity seem to be better predictors for wasting, while at individual child level the quality of nutrition plays an important role. The coefficient estimates for parental education remain similar and even increase in size for maternal education. The coefficient estimate for female head of the household continues to be negative but does not reach significance. This could be due to the model's single-stage nature, which cannot distinguish between the two counteracting effects of female-headed household (better quality of child's diet but lower income).

In sum, across all robustness specifications, children of mothers with secondary and higher education are less likely to suffer from wasting. Fathers' education either has no effect or, in the case of higher education, has a positive effect on the risk of wasting. The effect of the sex of the head of the household is robust for binary outcome measures and likely robust if specified as marginally decreasing for the continuous outcome measures.

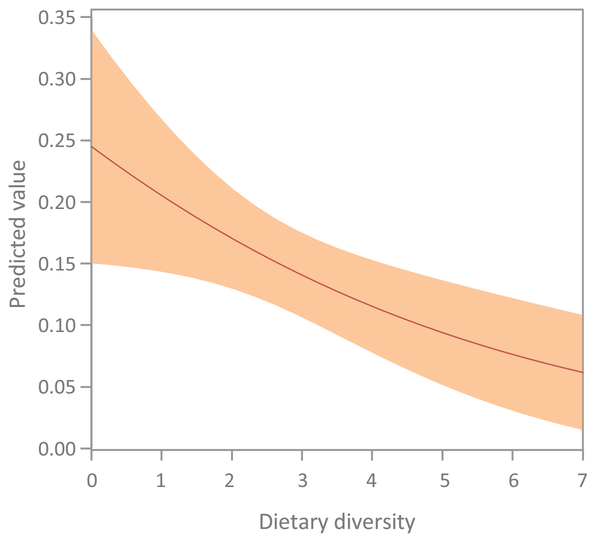
5.2 QUANTITIES OF INTEREST

FIGURE 4
Fitted values for dietary diversity by mother's education (first-stage regression)



Note: The vertical bars around the point estimates represent the 95.5 per cent confidence interval. Predicted values are calculated holding the other covariates at observed values.

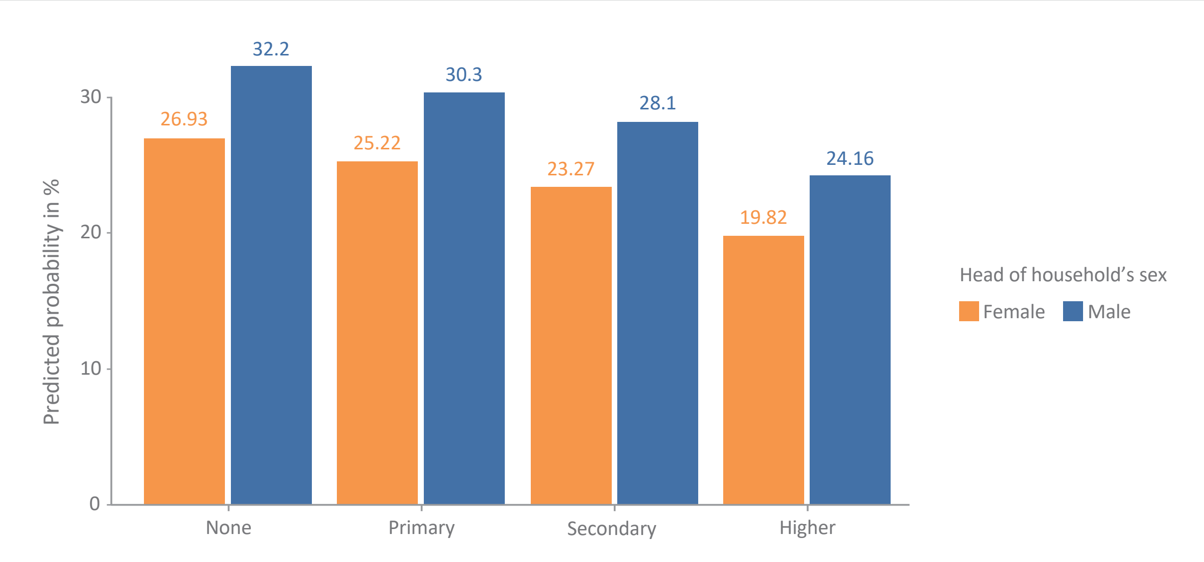
FIGURE 5
Predicted probability of wasting by dietary diversity (second-stage regression)



Note: The shaded grey area around the plot represents the 95.5 per cent confidence interval calculated based on bootstrap cluster-robust standard errors. Predicted probabilities are calculated holding the other co¬variates at observed values.

In logistic regression models, coefficient estimates represent changes in the outcome variable conditional on the predictor in log odds. To estimate the substantive effect of predictors in the context of my sample, I opt for calculating the Predicted Probabilities (PP)[11] and Average Marginal Effects (AME)[12] for the main variables of interest.

FIGURE 6
Predicted probability by mother's level of education and head of household's sex



Note: Predicted probabilities are calculated based on coefficient estimates from model 3 in Table 3. The other covariates from the model are held at constant mean (for continuous regressors) or median (for categorical regressors) values.

Figures 4 and 5 show how a mother's level of education reduces her children's risk of wasting via dietary diversity if the other covariates are held at **observed values**. In Figure 4, the predicted average number of aliments eaten by a child between 0 and 3 in our sample increases from about 2.4 to 2.9 when maternal education changes from no formal schooling to secondary or higher education. Figure 5 shows that at observed values, the probability of wasting decreases from 15–34 per cent (25 per cent on average) to about 2–12 per cent (6 per cent on average) if a child's food consumption moves from 0 to 7 essential food items. The average effect of increasing food diversity from the minimum to the maximum is, therefore, a reduction in risk of wasting by an average of 19 per cent. This is reflected by the highly significant marginal effect of -3.15 per cent per unit increase in dietary diversity (per food group consumed) displayed in Table 6.

The indirect effect of education on wasting via dietary diversity can also be interpreted in substantial terms. If maternal education increases from no formal schooling to higher or secondary education, a child's average dietary diversity increases by 0.5 aliments, and the risk of wasting decreases by 1.575 per cent (3.15 per cent times 0.5).

Moreover, greater maternal bargaining power in household resource allocation decisions decreases the risk of wasting. To find out how much the risk of a child wasting decreases with increasing maternal bargaining power, I calculate the predicted probability of wasting for different levels of maternal education and by sex of the head of the household. The other covariates are held constant at their mean (for continuous regressors) and median (for categorical regressors). The results are displayed in Figure 6.

On average, the likelihood of a child being wasted decreases by nearly one third from 32.2 per cent to 19.8 per cent if a child is born in a female-headed household where the mother has a university diploma, compared to a child born in a male-headed household with a mother without schooling. More generally, children from female-headed household are about 5 per cent less likely to be suffering from malnutrition than children from male-headed households. The AME of a female head of the household at observed covariate values is smaller, at -3.5 per cent (Table 6).

This suggests that some covariates that are associated with a higher risk of wasting—for instance, the socio-economic indicators—are correlated with the fact that a household is headed by a woman. By contrast, the AME of maternal education (-5.1 per cent) is relatively similar at observed compared to constant average values.

While a female head of the household directly lowers the risk of wasting, female-headed households are also economically weaker on average and provide less diverse diets to their children on average. Because dietary diversity affects the risk of wasting, the positive direct effect of a female head of the household on wasting may be outweighed by the negative indirect effect. Substantially, the results from the first-stage regression in column 4 of Table 3 in the previous subsection indicate that children from female-headed households consume 0.27 fewer food items than children from male-headed households. Reduced dietary diversity results in an indirectly 0.85 per cent higher risk of wasting for children from female-headed households.[13] Taken together with the direct AME of a female head of the household on the risk of wasting (-3.5 per cent), a child from a female-headed household is 2.75 per cent (-3.5 per cent + 0.85 per cent) less likely to suffer from wasting than a child from a male-headed household in my sample. The average marginal effects of all predictors are comprehensively displayed in Table 6.

TABLE 6
Average marginal effects of predictors on child's probability of wasting

Predictor	AME %	95% CI		P-Value	Sig.
		Lower	Upper		
Food diversity	-3.15	-5.50	-0.80	0.0086	***
Food shortage, HH	-0.06	-2.26	2.13	0.9542	
Breastfeeding < 7 months	-12.57	-18.70	-6.45	0.0001	***
Mother's level of education					
Primary	-1.25	-3.65	1.16	0.3097	
Secondary	-2.66	-6.01	0.70	0.1203	
Higher	-5.10	-9.37	-0.83	0.0192	**
Father's level of education					
Primary	0.51	-2.10	3.11	0.7042	
Secondary	0.59	-2.40	3.57	0.7008	
Higher	5.56	-0.24	11.36	0.0602	*
Father absent	1.26	-2.80	5.33	0.5422	
Female head of household	-3.50	-7.65	0.66	0.0988	*
Wealth quintiles					
Second	1.21	-1.78	4.20	0.4289	
Middle	-0.05	-3.87	3.77	0.9813	

→

Fourth	0.14	-5.02	5.30	0.9572	
Richest	-2.94	-8.81	2.93	0.3269	
Diarrhoea	2.49	0.48	4.50	0.0151	**
Female	-0.43	-2.13	1.26	0.6156	
Orphan	-2.20	-10.85	6.45	0.6185	
Rural area	1.97	-0.76	4.70	0.1581	
Household size	-0.03	-0.39	0.33	0.8766	
Improved sanitation	0.16	-2.74	3.06	0.9147	
Improved water source	-2.18	-5.19	0.83	0.1552	
State					
Northern	-7.66	-16.49	1.18	0.0893	*
River Nile	2.15	-6.33	10.63	0.6193	
Red Sea	-11.62	-18.74	-4.49	0.0014	***
Kassala	-6.99	-14.15	0.17	0.0558	*
Gadarif	-10.05	-16.02	-4.08	0.0010	***
Khartoum	-5.19	-13.25	2.87	0.2068	
Gezira	-8.85	-15.86	-1.84	0.0133	**
White Nile	-9.54	-15.90	-3.18	0.0033	***
Sinnar	-8.56	-15.67	-1.45	0.0182	**
Blue Nile	-12.31	-18.93	-5.69	0.0003	***
North Kordofan	-12.63	-18.25	-7.01	0.0000	***
South Kordofan	-11.17	-17.39	-4.94	0.0004	***
West Kordofan	-9.40	-16.44	-2.36	0.0089	***
South Darfur	-13.23	-19.41	-7.04	0.0000	***
Central Darfur	-13.16	-19.01	-7.31	0.0000	***
East Darfur	-13.82	-19.79	-7.85	0.0000	***
West Darfur	-10.19	-16.22	-4.16	0.0009	***

6 CONCLUSION

This paper investigated how and through which channels parental education affects wasting among children aged between 0 and 36 months in Sudan. The central argument was that mothers' level of education reduces children's risk of wasting independent of their household's economic situation and the father because education improves mothers' nutritional knowledge and bargaining power. Overall, the results from my statistical analyses corroborate that mothers' capabilities rather than households' access to food and economic resources lower children's risk of wasting.

Specifically, I find that mothers with more years of schooling provide a more diverse diet to their children independent of household-level food security and wealth. Greater dietary diversity, in turn, reduces the risk of wasting by up to 19 per cent on average. By contrast, fathers' education has no effect on children's diet when accounting for income. These findings suggest that raising mothers' awareness of appropriate child feeding practices is a promising way to prevent child malnutrition. Future programmes should increasingly focus on out-of-school girls and women who have received no formal education.

Furthermore, my analyses demonstrate that children of women with more education are less likely to suffer from wasting, independent of income. Likewise, children from female-headed households, where mothers are probably the main breadwinner, are also at lower risk of wasting, even if these households are less likely to provide a diverse diet. By contrast, paternal education has an opposing effect on children's weight-for-height measures. Fathers with a university diploma have children at greater risk of wasting than fathers without schooling. Fathers' absence from the household reduces the risk of wasting via a positive effect on the child's diet. My findings suggest that mothers' bargaining power in household resource allocation processes benefits their children, while fathers' education has an adverse effect.

More generally, my study confirms that wasting cannot simply be reduced through the use of universal cash transfers to improve the economic situation of households (Cheema et al. 2014). Instead, measures should address the social root causes of wasting and include capacity-building. If cash or in-kind transfers are used to reduce child malnutrition, they should be channelled to female caregivers, especially single mothers, and paired with educational activities. Well-designed transfers would not only benefit children but also increase mothers' relative decision-making power over household resources. To sum up, interventions should focus on empowering women via capacity-building and material support and by enhancing their legal and perceived autonomy from their husbands to increase their decision-making power.

APPENDIX A: SUMMARY STATISTICS

TABLE 7
Summary statistics from MICS5 2014 data, Sudan

Variable	Nw	Mean	Median	Min.	Max.
Wasting (1 = wasting)	12,402	0.16	0.00	0.00	1.00
Food diversity score (child)	8,264	2.28	2.00	0.00	7.00
Food shortage (household, 1 = yes)	96,943	0.31	0.00	0.00	1.00
Breastfeeding at WHO recommended age (1 = yes)	14,055	0.12	0.00	0.00	1.00
Age (in months)	14,081	28.90	29.00	0.00	59.00
Sex (1 = female)	97,024	0.50	0.00	0.00	1.00
Orphan (1 = yes)	49,457	0.05	0.00	0.00	1.00
Access to improved source of water (1 = yes)	96,864	0.13	0.00	0.00	1.00
Access to improved sanitation (1 = yes)	96,854	0.36	0.00	0.00	1.00
Household size (number of members)	97,049	7.01	7.00	1.00	26.00
Mother's level of education (0 = none, 3 = higher)	48,728	0.66	0.00	0.00	3.00
Father's level of education (0 = none, 3 = higher)[14]	41,189	0.82	1.00	0.00	3.00
Sick with diarrhoea past 2 weeks (1 = yes)	13,964	0.27	0.00	0.00	1.00
Wealth quintiles (1 = poorest, 5 = richest)	97,049	2.84	3.00	1.00	5.00
Household owns livestock (1 = yes)	96,890	0.00	0.00	0.00	0.00
Household owns agricultural land (1 = yes)	96,925	0.42	0.00	0.00	1.00

APPENDIX B: SIMPLE LOGISTIC REGRESSION MODELS (WITHOUT INSTRUMENTS)

TABLE 8
Logistic and logistic fixed-effect regression of wasting

	(1) Logit	(2) Logit FE
(Intercept)	-1.38 (0.18)***	-0.65 (0.21)***
Nutrition		
Food diversity	-0.01 (0.02)	0.01 (0.02)
Food shortage, HH	-0.00 (0.07)	0.04 (0.07)
Breastfeeding < 7 months	-0.59 (0.12)***	-0.53 (0.12)***
Mother's education (ref.: none)		
Primary	-0.09 (0.08)	-0.12 (0.08)
Secondary	-0.23 (0.12)**	-0.30 (0.12)**
Higher	-0.39 (0.19)**	-0.49 (0.19)***
Father's education (ref.: none)		
Primary	0.08 (0.09)	0.05 (0.09)
Secondary	0.06 (0.11)	0.03 (0.11)
Higher	0.34 (0.17)**	0.34 (0.17)**
Father absent	0.05 (0.15)	0.06 (0.15)
Female head of household	-0.16 (0.16)	-0.18 (0.16)
Health child		
Diarrhoea	0.21 (0.07)***	0.16 (0.07)**
Socio-demographics, child		
Age (months)	-0.01 (0.00)**	-0.01 (0.00)***
Female	-0.02 (0.06)	-0.02 (0.06)
Orphan	-0.13 (0.30)	-0.21 (0.31)
Socio-demographics, HH		
Rural area	0.21 (0.09)**	0.19 (0.10)*
Improved water source	-0.21 (0.11)*	-0.18 (0.11)*
Improved sanitation	-0.02 (0.10)	-0.01 (0.10)
Household size	0.00 (0.01)	-0.00 (0.01)
Income quintile (ref.: poorest)		
Second	0.01 (0.10)	0.06 (0.10)
Middle	-0.10 (0.12)	-0.07 (0.13)
Fourth	-0.04 (0.14)	-0.11 (0.17)
Richest	-0.30 (0.18)*	-0.45 (0.21)**
State FE (ref.: North Darfur)		
Northern		-0.73 (0.26)***
River Nile		-0.06 (0.20)
Red Sea		-0.81 (0.25)***
Kassala		-0.36 (0.20)*
Gadarif		-0.77 (0.18)***
Khartoum		-0.41 (0.22)*

→

Gezira		-0.61 (0.20)***
White Nile		-0.72 (0.19)***
Sinnar		-0.62 (0.20)***
Blue Nile		-1.03 (0.20)***
North Kordofan		-0.89 (0.18)***
South Kordofan		-0.84 (0.18)***
West Kordofan		-0.80 (0.21)***
West Darfur		-0.66 (0.18)***
South Darfur		-0.95 (0.21)***
Central Darfur		-0.85 (0.19)***
East Darfur		-0.99 (0.20)***
AIC	6,437.81	6,393.62
BIC	6,602.61	6,675.15
Log likelihood	-3,194.91	-3,155.81
Deviance	6,389.81	6,311.62
Num. obs.	7,091	7,091

Note: Cluster-robust standard errors reported in parenthesis. Clustering is at the enumeration level (primary sampling unit); ***p < 0.01, **p < 0.05, *p < 0.1.

APPENDIX C: ROBUSTNESS CHECKS—WASTING

TABLE 9

Robustness checks for continuous weight-for-height scores and severe malnutrition

	WHZ score		SAM (< 3SD)
	Second stage	**First stage**	**Second stage**
(Intercept)	-1.41 (0.14)***	0.92 (0.11)***	-1.39 (0.43)***
Nutrition			
Food diversity	0.01 (0.04)		-0.25 (0.15)*
Residuals stage 1			0.30 (0.16)**
Residuals stage 1			
Food shortage, HH	-0.04 (0.04)	-0.15 (0.04)***	-0.05 (0.12)
Breastfeeding	0.54 (0.12)***	-1.59 (0.05)***	-0.80 (0.38)**
Mother's education (ref.: none)			
Primary	0.03 (0.04)	0.14 (0.04)***	-0.11 (0.14)
Secondary	0.15 (0.06)**	0.42 (0.06)***	-0.44 (0.21)**
Higher	0.28 (0.09)***	0.37 (0.09)***	-0.04 (0.38)
Father's education (ref.: none)			
Primary	-0.04 (0.04)	-0.03 (0.04)	0.09 (0.14)
Secondary	-0.03 (0.06)	0.03 (0.06)	0.01 (0.20)
Higher	-0.03 (0.09)	0.13 (0.09)	0.01 (0.33)
Father absent	-0.00 (0.07)	0.11 (0.07)	0.09 (0.26)
Female head of household	0.09 (0.08)	-0.27 (0.08)***	-0.53 (0.29)*
Health child			
Diarrhoea	-0.11 (0.04)***	0.07 (0.04)*	-0.09 (0.13)
Socio-demographics, child			
Female	0.05 (0.03)	-0.03 (0.03)	-0.14 (0.11)
Orphan	-0.09 (0.15)	0.17 (0.14)	0.27 (0.55)
Socio-demographics, HH			
Rural area	-0.11 (0.05)**	-0.26 (0.05)***	0.11 (0.17)
Improved water source	0.08 (0.05)	0.11 (0.05)**	-0.27 (0.18)
Improved sanitation	-0.02 (0.05)	0.11 (0.05)**	-0.09 (0.15)
Household size	-0.00 (0.01)	-0.00 (0.01)	0.00 (0.02)
Income quintile (ref.: poorest)			
Second	0.02 (0.05)	0.20 (0.05)***	0.09 (0.17)
Middle	0.07 (0.06)	0.36 (0.06)***	0.27 (0.23)
Fourth	0.07 (0.08)	0.64 (0.08)***	0.11 (0.29)
Richest	0.25 (0.11)**	1.06 (0.10)***	-0.25 (0.37)
Poor household instruments			
Age (months)		0.05 (0.00)***	
HH has livestock		0.14 (0.04)***	
HH owns agricultural land		0.16 (0.04)***	
State FE (ref.: North Darfur)			
Northern	0.50 (0.13)***	1.18 (0.12)***	-0.54 (0.51)

→

River Nile	0.11 (0.12)	0.70 (0.11)***	0.28 (0.34)
Red Sea	0.70 (0.13)***	0.36 (0.12)***	-0.87 (0.49)*
Kassala	0.30 (0.11)***	-0.10 (0.10)	-0.71 (0.33)**
Gadarif	0.68 (0.10)***	0.73 (0.10)***	-0.65 (0.29)**
Khartoum	0.24 (0.11)**	0.56 (0.11)***	-0.26 (0.40)
Gezira	0.72 (0.11)***	0.41 (0.11)***	-0.85 (0.36)**
White Nile	0.52 (0.11)***	0.62 (0.10)***	-0.90 (0.34)***
Sinnar	0.30 (0.11)***	0.50 (0.10)***	-0.57 (0.33)*
Blue Nile	0.71 (0.11)***	1.01 (0.10)***	-1.18 (0.36)***
North Kordofan	0.60 (0.10)***	0.33 (0.10)***	-0.92 (0.32)***
South Kordofan	0.70 (0.10)***	0.65 (0.09)***	-0.82 (0.30)***
West Kordofan	0.46 (0.11)***	1.02 (0.10)***	-0.91 (0.36)**
West Darfur	0.54 (0.10)***	0.23 (0.10)**	-0.38 (0.30)
South Darfur	0.41 (0.10)***	0.36 (0.09)***	-1.09 (0.35)***
Central Darfur	0.73 (0.10)***	0.02 (0.10)	-1.18 (0.38)***
East Darfur	0.52 (0.10)***	0.31 (0.09)***	-1.17 (0.33)***
Num. obs.	7,082	8,068	7,082
R^2	0.06	0.43	
Adj. R^2	0.05	0.43	
RMSE	1.35	1.44	
AIC			2,901.08
BIC			3,182.56
Log likelihood			-1,409.54
Deviance			2,819.08

Note: Cluster-robust standard errors (bootstrapped, 500 draws with replacement for models 3 and 4) are reported in parenthesis. Clustering is at the enumeration level (primary sampling unit); ***p < 0.01, **p < 0.05, *p < 0.1.

TABLE 10
Fixed-effects model with household food diversity score

	FAO FD indicator		UNICEF FD indicator	
	(1) Logit FE	(2) Logit FE	(3) Logit FE	(4) Logit FE
(Intercept)	-0.40 (0.19)*	-0.43 (0.25)	-0.57 (0.16)***	-0.54 (0.22)*
Nutrition				
Food diversity, HH_{FAO}	-0.06 (0.02)*	-0.03 (0.03)		
Food diversity, HH_{UNICEF}			-0.07 (0.03)*	-0.03 (0.03)
Food shortages, HH	0.00 (0.07)	0.01 (0.07)	0.01 (0.07)	0.01 (0.07)
Breastfeeding	-0.34 (0.09)***	-0.59 (0.12)***	-0.34 (0.09)***	-0.59 (0.12)***
Mother's education (ref.: none)				
Primary	-0.13 (0.08)	-0.10 (0.08)	-0.14 (0.08)	-0.11 (0.08)
Secondary	-0.36 (0.11)**	-0.27 (0.12)*	-0.37 (0.11)**	-0.27 (0.12)*
Higher	-0.59 (0.18)**	-0.43 (0.19)*	-0.60 (0.18)***	-0.43 (0.19)*
Father's education (ref.: none)				
Primary	0.04 (0.09)	0.04 (0.09)	0.03 (0.09)	0.04 (0.09)
Secondary	-0.04 (0.11)	0.02 (0.11)	-0.05 (0.11)	0.01 (0.11)
Higher	0.23 (0.17)	0.32 (0.17)	0.22 (0.17)	0.32 (0.17)
Father absent	0.00 (0.14)	0.04 (0.15)	-0.00 (0.14)	0.04 (0.15)
Female head of household	-0.11 (0.15)	-0.12 (0.15)	-0.10 (0.15)	-0.12 (0.15)
Health child				
Diarrhoea	0.18 (0.07)*	0.17 (0.07)*	0.18 (0.07)*	0.17 (0.07)*
Socio-demographics, child				
Age (in months)		-0.01 (0.00)***		-0.01 (0.00)***
Female		-0.02 (0.06)		-0.02 (0.06)
Orphan		-0.11 (0.29)		-0.11 (0.29)
Socio-demographics, HH				
Rural area		0.19 (0.10)		0.19 (0.10)
Improved water source		-0.15 (0.11)		-0.15 (0.11)
Improved sanitation		-0.00 (0.10)		-0.01 (0.10)
Household size		-0.00 (0.01)		-0.00 (0.01)
Wealth quintiles				
Second		0.06 (0.10)		0.06 (0.10)
Middle		-0.06 (0.13)		-0.06 (0.13)
Fourth		-0.08 (0.17)		-0.09 (0.17)
Richest		-0.40 (0.21)		-0.42 (0.21)*
State FE (Ref.: North Darfur)				
Northern	-0.72 (0.25)**	-0.64 (0.26)*	-0.74 (0.25)**	-0.65 (0.26)*
River Nile	-0.10 (0.19)	-0.03 (0.20)	-0.12 (0.19)	-0.03 (0.20)
Red Sea	-0.87 (0.24)***	-0.76 (0.24)**	-0.87 (0.24)***	-0.75 (0.24)**
Kassala	-0.39 (0.20)	-0.32 (0.20)	-0.38 (0.20)	-0.32 (0.20)
Gadarif	-0.68 (0.17)***	-0.69 (0.18)***	-0.69 (0.17)***	-0.69 (0.18)***
Khartoum	-0.56 (0.20)**	-0.33 (0.22)	-0.59 (0.20)**	-0.34 (0.22)
Gezira	-0.65 (0.19)***	-0.58 (0.20)**	-0.66 (0.19)***	-0.58 (0.20)**

→

White Nile	-0.70 (0.18)***	-0.66 (0.19)***	-0.72 (0.18)***	-0.66 (0.19)***
Sinnar	-0.61 (0.19)**	-0.57 (0.20)**	-0.63 (0.19)***	-0.58 (0.20)**
Blue Nile	-0.96 (0.19)***	-0.95 (0.20)***	-0.99 (0.18)***	-0.96 (0.20)***
North Kordofan	-0.83 (0.19)***	-0.85 (0.19)***	-0.85 (0.19)***	-0.86 (0.19)***
South Kordofan	-0.79 (0.16)***	-0.77 (0.17)***	-0.80 (0.16)***	-0.78 (0.17)***
West Kordofan	-0.73 (0.21)***	-0.72 (0.21)***	-0.75 (0.21)***	-0.73 (0.21)***
West Darfur	-0.66 (0.18)***	-0.62 (0.19)***	-0.67 (0.18)***	-0.62 (0.19)***
South Darfur	-0.90 (0.20)***	-0.87 (0.20)***	-0.90 (0.20)***	-0.87 (0.20)***
Central Darfur	-0.82 (0.18)***	-0.82 (0.19)***	-0.82 (0.18)***	-0.82 (0.19)***
East Darfur	-0.93 (0.20)***	-0.93 (0.20)***	-0.93 (0.20)***	-0.93 (0.20)***
AIC	6,576.54	6,549.10	6,578.52	6,549.78
BIC	6,783.59	6,831.96	6,785.57	6,832.64
Log likelihood	-3,258.27	-3,233.55	-3,259.26	-3,233.89
Deviance	6,516.54	6,467.10	6,518.52	6,467.78
Num. obs.	7,344	7,325	7,344	7,325

Note: Cluster-robust standard errors reported in parenthesis. Clustering is at the enumeration level (primary sampling unit); ***p < 0.01, **p < 0.05, *p < 0.1.

REFERENCES

Abuya, B.A., E.O. Onsomu, J.K. Kimani, and D. Moore. 2011. "Influence of Maternal Education on Child Immunization and Stunting in Kenya." *Maternal and Child Health Journal* 15(8): 1389–1399. <https://doi.org/10.1007/s10995-010-0670-z>. Accessed 2 July 2019.

Akombi, B., K. Agho, J. Hall, N. Wali, A. Renzaho, and D. Merom. 2017a. "Stunting, Wasting and Underweight in Sub-Saharan Africa: A Systematic Review." *International Journal of Environmental Research and Public Health* 14(8): 863. <https://doi.org/10.3390/ijerph14080863>. Accessed 2 July 2019.

Akombi, B., K. Agho, D. Merom, J. Hall, and A. Renzaho. 2017b. "Multilevel Analysis of Factors Associated with Wasting and Underweight among Children Under-Five Years in Nigeria." *Nutrients* 9(1): 44. <https://doi.org/10.3390/nu9010044>. Accessed 2 July 2019.

Alderman, H., and D.D. Headey. 2017. "How Important is Parental Education for Child Nutrition?" *World Development* 94: 448–464. <https://doi.org/10.1016/j.worlddev.2017.02.007>. Accessed 2 July 2019.

Bashir, A.O., G.H. Ibrahim, I.A. Bashier, and I. Adam. 2013. "Neonatal mortality in Sudan: Analysis of the Sudan household survey, 2010." *BMC Public Health* 13(1): 287 <https://doi.org/10.1186/1471-2458-13-287>. Accessed 2 July 2019.

Beiersmann, C., J. Bermejo Lorenzo, M. Bountogo, J. Tiendrebeogo, S. Gabrysch, M. Ye, A. Jahn, and O. Muller. 2013. "Malnutrition Determinants in Young Children from Burkina Faso." *Journal of Tropical Pediatrics* 59(5): 372–379. <https://doi.org/10.1093/tropej/fmt037>. Accessed 2 July 2019.

Branisa, B., S. Klasen, and M. Ziegler. 2013. "Gender Inequality in Social Institutions and Gendered Development Outcomes." *World Development* 45: 252–268. <https://doi.org/10.1016/j.worlddev.2012.12.003>. Accessed 2 July 2019.

CBS Sudan and UNICEF Sudan. 2016. *Multiple Indicator Cluster Survey 2014 of Sudan. Final Report*. Khartoum: United Nations Children's Fund and Central Bureau of Statistics.

Cheema, I., M. Farhat, S. Hunt, S. Javeed, L. Pellerano, and S. O'Leary. 2014. *Benazir Income Support Programme: First follow-up impact evaluation report*. Oxford: Oxford Policy Management. <https://www.opml.co.uk/files/Publications/7328-evaluating-pakistans-flagship-social-protection-programme-bisp/bisp-first-follow-up-impact-evaluation-report.pdf?noredirect=1>. Accessed 2 July 2019.

Cochrane, S.H., J. Leslie, and D.J. O'Hara. 1982. "Parental education and child health: Intracountry evidence." *Health Policy and Education* 2(3–4): 213–250. <https://doi.org/10.1016/0165-2281(82)90011-X>. Accessed 2 July 2019.

Coupé, T. 2005. "Bias in Conditional and Unconditional Fixed Effects Logit Estimation: A Correction." *Political Analysis* 13(3): 292–295.

Desai, S., and S. Alva. 1998. "Maternal Education and Child Health: Is There a Strong Causal Relationship?" *Demography* 35(1): 71. <https://doi.org/10.2307/3004028>. Accessed 2 July 2019.

Duflo, E. 2003. "Grandmothers and Granddaughters: Old-Age Pensions and Intrahousehold Allocation in South Africa." *The World Bank Economic Review* 17(1) 1–25.

Duflo, E. 2012. "Women Empowerment and Economic Development." *Journal of Economic Literature* 50(4): 1051–1079. <https://doi.org/10.1257/jel.50.4.1051>. Accessed 2 July 2019.

Ekbrand, H., and B. Halleröd. 2018. "The more gender equity, the less child poverty? A multilevel analysis of malnutrition and health deprivation in 49 low- and middle-income countries." *World Development* 108: 221–230. <https://doi.org/10.1016/j.worlddev.2018.01.028>. Accessed 2 July 2019.

Elshibly, E.M., and G. Schmalisch. 2008. "The effect of maternal anthropometric characteristics and social factors on gestational age and birth weight in Sudanese newborn infants." *BMC Public Health* 8(1): 244. <https://doi.org/10.1186/1471-2458-8-244>. Accessed 2 July 2019.

Famine Early Warning System. 2014. "East Africa Food Security Classification (April 2014 - September 2014)." FEWS NET Data Center website. <https://bit.ly/2MK0qdO>. Accessed 2 July 2019.

Fawzi, W.W., M.G. Herrera, D.L. Spiegelman, A. El Amin, P. Nestel, and K.A. Mohamed. 1997. "A prospective study of malnutrition in relation to child mortality in the Sudan." *The American Journal of Clinical Nutrition* 65(4): 1062–1069.

Frempong, R.B., and S.K. Annim. 2017. "Dietary diversity and child malnutrition in Ghana." *Heliyon* 3(5): e00298. <https://doi.org/10.1016/j.heliyon.2017.e00298>. Accessed 2 July 2019.

Frost, M.B., R. Forste, and D.W. Haas. 2005. "Maternal education and child nutritional status in Bolivia: Finding the links." *Social Science & Medicine* 60(2): 395–407. <https://doi.org/10.1016/j.socscimed.2004.05.010>. Accessed 2 July 2019.

Güneş, P.M. 2015. "The role of maternal education in child health: Evidence from a compulsory schooling law." *Economics of Education Review* 47: 1–16. <https://doi.org/10.1016/j.econedurev.2015.02.008>. Accessed 2 July 2019.

Hassan, A.A., M.S. Abubaker, E.A. Radi, and I. Adam. 2009. "Education, prenatal care, and poor perinatal outcome in Khartoum, Sudan." *International Journal of Gynecology & Obstetrics* 105(1): 66–67. <https://doi.org/10.1016/j.ijgo.2008.10.026>. Accessed 2 July 2019.

House, W.J. 1988. "The Status of Women in the Sudan." *The Journal of Modern African Studies* 26(2): 277–302.

Ibnouf, F.O. 2009. "The Role of Women in Providing and Improving Household Food Security in Sudan: Implications for Reducing Hunger and Malnutrition." *Journal of International Women's Studies* 10(4): 144–167.

Ibnouf, A.H., H.W. Van den Borne, and J.A.M. Maarse. 2007. "Factors influencing immunisation coverage among children under five years of age in Khartoum State, Sudan." *South African Family Practice* 49(8): 14–14f. <https://doi.org/10.1080/20786204.2007.10873611>. Accessed 2 July 2019.

IFPRI. 2014. *Global Nutrition Report 2014: Actions and Accountability to Accelerate the World's Progress on Nutrition*. Washington, DC: International Food Policy Research Institute. <https://doi.org/10.2499/9780896295643>. Accessed 2 July 2019.

Katz, E. 2001. "Bias in Conditional and Unconditional Fixed Effects Logit Estimation." *Political Analysis* 9(4): 379–384.

Kennedy, G., T. Ballard, and M.C. Dop. 2011. *Guidelines for measuring household and individual dietary diversity*. Rome: Food and Agriculture Organization of the United Nations.

Koladjo, B.F., S. Escolano, and P. Tubert-Bitter. 2018. "Instrumental variable analysis in the context of dichotomous outcome and exposure with a numerical experiment in pharmacoepidemiology." *BMC Medical Research Methodology* 18(1): 61. <https://doi.org/10.1186/s12874-018-0513-y>. Accessed 2 July 2019.

Leeper, T.J. 2017. "Interpreting regression results using average marginal effects with R's margins." Comprehensive R Archive Network. <https://rdrr.io/cran/margins/f/inst/doc/TechnicalDetails.pdf>. Accessed 2 July 2019.

Mahaffy, K. A., and S. K. Ward. 2002. "The Gendering of Adolescents' Childbearing and Educational Plans: Reciprocal Effects and the Influence of Social Context". *Sex Roles* 46(11): 403–17. <https://doi.org/10.1023/A:1020413630553>. Accessed 2 July 2019.

Marphatia, A.A., T.J. Cole, C. Grijalva-Eternod, and J.C.K. Wells. 2016. "Associations of gender inequality with child malnutrition and mortality across 96 countries." *Global Health, Epidemiology and Genomics* 1: e6. <https://doi.org/10.1017/gheg.2016.1>. Accessed 2 July 2019.

Mason, J.B., J.M. White, L. Heron, J. Carter, C. Wilkinson, and P. Spiegel. 2012. "Child Acute Malnutrition and Mortality in Populations Affected by Displacement in the Horn of Africa, 1997–2009." *International Journal of Environmental Research and Public Health* 9(3): 791–806. <https://doi.org/10.3390/ijerph9030791>. Accessed 2 July 2019.

Melander, E., T. Pettersson, and L. Themnér. 2016. "Organized violence, 1989–2015." *Journal of Peace Research* 53(5): 727–742. <https://doi.org/10.1177/0022343316663032>. Accessed 2 July 2019.

Nielsen, J., C. Prudhon, and X. Radigues. 2011. "Trends in malnutrition and mortality in Darfur, Sudan, between 2004 and 2008: A meta-analysis of publicly available surveys." *International Journal of Epidemiology* 40(4): 971–984. <https://doi.org/10.1093/ije/dyr010>. Accessed 2 July 2019.

Onyango, A., K. Tucker, and T. Eisemon. 1994. "Household headship and child nutrition: A case study in Western Kenya." *Social Science & Medicine* 39(12): 1633–1639. <https://doi.org/10.1016/0277-9536(94)90077-9>. Accessed 2 July 2019.

Richards, E. 2011. *Gender influences in child survival, health and nutrition: a narrative review*. New York and Liverpool: United Nations Children's Fund and Liverpool School of Tropical Medicine. <https://www.unicef.org/Gender_Influences_on_Child_Survival_a_Narrative_review.pdf>. Accessed 2 July 2019.

Richards, E., S. Theobald, A. George, J.C. Kim, C. Rudert, K. Jehan, and R. Tolhurst. 2013. "Going beyond the surface: Gendered intra-household bargaining as a social determinant of child health and nutrition in low and middle income countries." *Social Science & Medicine* 95: 24–33. <https://doi.org/10.1016/j.socscimed.2012.06.015>. Accessed 2 July 2019.

Sen, A. 1990. "Gender and Cooperative Conflicts." In *Persistent Inequalities*, edited by I. Tinker. New York: Oxford University Press.

Smith, L.C., U. Ramakrishnan, A. Ndiayel, R. Martorel, and L. Haddad. 2003. *The importance of women's status for child nutrition in developing countries*. Washington, DC: International Food Policy Research Institute.

Sommet, N., and D. Morselli. 2017. "Keep Calm and Learn Multilevel Logistic Modeling: A Simplified Three-Step Procedure Using Stata, R, Mplus, and SPSS." *International Review of Social Psychology* 30(1): 203–218. <https://doi.org/10.5334/irsp.90>. Accessed 2 July 2019.

Sundberg, R., and E. Melander. 2013. "Introducing the UCDP Georeferenced Event Dataset." *Journal of Peace Research* 50(4): 523–532.

Terza, J.V. 2018. "Two-Stage Residual Inclusion Estimation in Health Services Research and Health Economics." *Health Services Research* 53(3): 1890–1899. <https://doi.org/10.1111/1475-6773.12714>. Accessed 2 July 2019.

Terza, J.V., A. Basu, and P.J. Rathouz. 2008. "Two-stage residual inclusion estimation: Addressing endogeneity in health econometric modeling." *Journal of Health Economics* 27(3): 531–543. <https://doi.org/10.1016/j.jhealeco.2007.09.009>. Accessed 2 July 2019.

WHO, UNICEF, USAID, AED, UCDAVIS, and IFPRI. 2008. *Indicators for assessing infant and young child feeding practices: Conclusions of a consensus meeting held 6-8 November 2007 in Washington D.C., USA*. Washington, DC: World Health Organization.

NOTES

2. Sudan was not part of the 56 countries, as the study used data from USAID's Demographic Health Survey, which has not been conducted in Sudan.

3. According to Sen (1990), functionings refer to a person's 'natural' abilities independent of external constraints—for example, the age s/he could reach. Capabilities refer to his/her freedom to achieve these functionings. While functionings could be considered initial endowments, capabilities are external constraints or opportunities for using these endowments.

4. Water source is improved if piped water (into dwelling, compound, yard or plot, to neighbour, public tap/standpipe), tube well/borehole, protected well or spring and rainwater collection. An individual has access if s/he spends less than 30 minutes to walk to and return from the water source.

5. **Improved** sanitation facilities ensure hygienic separation of human excreta from human contact. **Improved** facilities include flush or pour-flush toilet/latrine to: piped sewer system, septic tank pit latrine, ventilated improved pit latrine, pit latrine with slab, or composting toilet. A child has access to this facility if it is not shared with another household.

6. Concerns have been raised about using fixed effects in a logistic regression model. An alternative suggestion is to use conditional maximum likelihood estimates for fixed effects. These, however, are computationally intensive, cannot deal with missing data and cannot estimate coefficients for the incidental parameters—i.e. the fixed effect. I use unconditional maximum likelihood estimates because it has been shown that estimates are unbiased if the number of clusters (states) is fixed and the number of observations within the cluster is sufficiently large (T >20) (Coupé 2005; Katz 2001).

7. I also used primary sampling unit fixed effects. Yet their inclusion did not change the results; indeed, the coefficient estimates for education even increased in size. Results from this specification are not displayed here but are available on request.

8. For consistent estimates of this lower-level regression in a logistic multi-level model, at least 50 Level 1 observations are necessary. The minimum number of Level 2 units suggested for estimating the random intercepts in a logistic multi-level model is at least 40 (Sommet and Morselli 2017).

9. In column 2 of Table 8 in Annex 8.2, I compute the same model as in columns 1 and 3 of Table 3 but without including the residuals of the first-stage regression on the endogenous regressor, dietary diversity. The coefficient estimate is indifferent from zero—i.e. if not accounting for endogeneity, the effect of mothers' nutritional knowledge on wasting remains undetected.

10. I also added mothers' marital status (married vs. formerly married—i.e. divorced or widowed) to the regression models. I found no significant effect of marital status on wasting. Results from these additional analyses are available on request.

11. PP indicate the likelihood of wasting if a variable increases by one unit conditional on other covariates (usually held constant at their mean and median values). In some cases, it might be sensible to hold covariates at constant values to see the net effect of a predictor of interest. However, this multidimensional mean of the covariates held constant might not be observed in the real sample (Leeper 2017). Hence, PP are hypothetical.

12. The AME indicates changes in the mean of the predicted linear values calculated at observed level of the covariates and conditional on the predictor of interest.

13. AME for dietary diversity is -3.15 per cent; if multiplied by the difference in dietary diversity between children from female- and male-headed households, -0.27, this results in a 0.85 per cent higher risk of wasting

14. Note that in the summary statistics the category 'Father absent from household' is excluded, as the ordinal and binary categorical variables were transformed into numeric values for calculating mean and median values.

International Policy Centre for Inclusive Growth (IPC-IG)

SBS, Quadra 1, Bloco J, Ed. BNDES, 13º andar
70076-900 Brasília, DF - Brazil
Telephone: +55 61 2105 5000

ipc@ipc-undp.org ▪ www.ipcig.org