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Rural women's empowerment and children's food and nutrition security in Bangladesh

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ABSTRACT

Women's empowerment and child stunting remain key development challenges in Bangladesh. The objective of this study is to analyse the influence of female empowerment in agriculture, on child food security. This study uses household survey data from two waves of the Bangladesh Integrated Household Survey (BIHS), a rich panel dataset of over 6500 households in rural Bangladesh which includes detailed child anthropometric measurements of children under five years old. We adopt a multidimensional approach to female empowerment by analysing five key empowerment indicators from the *Women's Empowerment in Agriculture Index* (WEAI). The multivariate regression analysis explores the relationship between five key empowerment indicators and child stunting, a proxy for child food security. Our empirical analysis finds that women's autonomy in household productive decisions and confidence in public speaking are associated with significantly higher children's height-for-age z-scores (*haz*) and a decreased probability of stunting in this sample. These results suggest expanding women's empowerment is likely to complement nutritional interventions to reduce stunting in Bangladesh, while making progress towards other social and development goals.

1. Introduction

The World Food Programme's Strategic Review of Food Security and Nutrition in Bangladesh (2016) highlights the progress made in terms of improved food availability and access since the 1970s, which has been accompanied by significant improvements in maternal and child nutrition. Although Bangladesh has experienced one of the largest reductions in child stunting in recent years (Headey, 2015; Jain, 2018), it has among the highest stunting rates in the world. Using data from the *Bangladesh Demographic Health Survey* 2014, Islam et al. (2019) find that 36.2% of children under five years of age are stunted, 14.3% are wasted and 33% are underweight. About 6 million Bangladeshi children still suffer from stunting, and 2.4 million from wasting (Hussain, Talukdar, & Ahmed, 2015), and this poses a significant issue for policy makers as the effects of stunting, which include cognitive impairment and an increased risk of chronic illness, manifest as both private and public costs.

There has been growing attention in the literature to the gender dimension of household food and nutrition security (Quisumbing, 2003). A frequent observation in South Asia is that child undernutrition continues to prevail at alarmingly high rates, higher than would be expected given its economic development in past decades – referred to as the Asian Enigma (Ramalingaswami et al., 1996). Women's low status has been hypothesised as a cause, however the existing empirical evidence is mixed.

As in many countries in South Asia, women in Bangladesh face additional constraints on their ability to improve their economic, physical, and psychological wellbeing due to the adverse effects of gender discrimination throughout the life cycle. This in turn limits women's abilities to improve the economic and nutritional status of their families and communities, particularly given the close link between maternal and infant health. Social norms such as early marriage, low maternal education and unequal resource and power distribution within the home have been associated with poor maternal nutrition and child stunting (Bhagowalia, Menon, Quisumbung & Soundararajan, 2012).

In the specific context of agriculture, Gillespie et al. (2018) show that in countries such as Bangladesh where nearly half the population is employed in agriculture, agriculture labour conditions can influence women's empowerment and their control over decision making with regards to food and health care. They have identified six pathways through which agriculture can influence child nutrition, and three of these relate to women's role in agriculture. These

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include the effects of women's empowerment on control over nutrition-related resources, the influence of women's agriculture employment on childcare and child feeding practices, and the influence of women's employment on their own nutrition and health status. The aim of this paper is to empirically analyse the relationship between women's empowerment in agriculture and its influence on children's food and nutrition security in rural Bangladesh.

The health of mothers and children are intimately linked. The literature has identified three conceptual pathways through which women's status influences child nutrition and household-level food security. Mothers influence the nutritional status of their children through: (i) their own health in birth, childhood and adolescence (Black et al., 2013; Abu-Saad & Fraser, 2010); (ii) the provision of appropriate breastfeeding and complementary feeding practices (Stewart, Iannotti, Dewey, Michaelsen, & Onyango, 2013); and (iii) their influence over the intrahousehold allocation of resources (Thomas, 1997).

Maternal health is a key determinant of a child's early development (Black et al., 2013). Low maternal BMI and height have been widely identified as primary predictors of low birth weight, an important indicator of both maternal and infant health that affects at least one-fifth of Bangladeshi infants (Hussain et al., 2015). Low status of women may manifest in poor child nutrition outcomes through poor maternal nutritional status and health before, during and after pregnancy, including mental health and self-esteem. In addition, mothers' lifetime experience of intimate partner violence is also associated with an increased risk of low birth weight globally, including in a recent hospital-based study of Bangladesh (Hill, Pallitto, McCleary-Sills, & Garcia-Moreno, 2016; Ferdos & Rahman, 2017).

The presence of socio-cultural norms that discriminate against females can deteriorate mothers' physical and mental health, with implications for child nutrition and food security. The significant association between maternal and child nutritional status runs in both directions. Maternal malnutrition significantly increases the risk of low birth weight and subsequently infant morbidity and mortality, for example Muthayya (2009). At the same time the additional nutritional stresses of pregnancy exacerbate the problems of the mother's own nutritional status, and her morbidity and mortality in later life (Alam, van Raaij, Hautvast, Yunus, & Fuchs, 2003; Rah et al., 2008).

In addition, maternal depression and anxiety has been independently associated with risk of low birth weight in South Asian countries, more than doubling the risk in a population study of rural Bangladesh (Nasreen, Kabir, Forsell, & Edhborg, 2010). A number of community-level studies have found a high prevalence of antenatal depression in the region, including in rural populations (Rahman, Iqbal, & Harrington, 2003; Gausia, Fisher, Ali, & Oosthuizen, 2009). The latter study found that the risk factors for depression often had their roots in patriarchal norms; pregnant women in rural Bangladesh were two to three times more likely to be depressed if they had no help from their husband or mother-in-law, if they had a poor relationship with their mother-in-law, or if they were beaten by their husband during and before their current pregnancy.

Furthermore, appropriate infant feeding practices in the first two to three years of life are essential for the survival, growth and development of infants and children, particularly in developing countries (Michaelsen, Weaver, Branca, & Robertson, 2003; Black et al., 2013; Saha et al., 2008). It has been hypothesised that women who are better educated, have greater decision-making abilities, participate more in their communities, and have higher levels of confidence are better able to adopt appropriate feeding practices and care for their children (Smith, Ramakrishnan, Ndiaye, Haddad, & Martorell, 2003).

Given this context, our analysis offers three main contributions to the existing literature. Firstly, it draws on two waves of the Bangladesh Integrated Household Survey (BIHS), a rich panel dataset of over 6500 households in rural Bangladesh. This is an important complement to existing cross-sectional data as it can account for unobserved heterogeneity across individuals, which is likely to have a large influence on both empowerment and nutrition.

Secondly, we adopt a multidimensional approach to female empowerment by analysing the five key empowerment indicators from the newly developed *Women's Empowerment in Agriculture Index* (WEAI), an innovative multidimensional weighted index of ten empowerment indicators across five domains of empowerment (5DE), each of which can also be studied individually.[1] The use of the WEAI is particularly relevant in this study as it was primarily collected to measure the empowerment of women in rural agricultural households, and is more comprehensive than previous research, where proxy indicators or a single dimension of empowerment were typically used. More importantly, the 5DE relate to the mothers of the children in our sample, so the use of the WEAI provides a more detailed picture of the relationship between specific empowerment indicators and child stunting in rural Bangladesh. This also allows us to test Gillespie et al.'s (2018) hypothesis that in rural settings, female empowerment influences child nutrition. To the best of our knowledge there is no published research linking WEAI to child nutrition in Bangladesh.

The key findings from this analysis are that women's overall autonomy measured using the five domains of empowerment (5DE) is significantly associated with better height-for-age z-scores (*haz)* children aged between 6 and 59 months in the pooled sample, and better household dietary diversity. The specific empowerment measures have mixed results, with autonomy in making productive decisions and confidence speaking in public being significantly associated with improvements in children's height-for-age z-scores (*haz),* and a decrease in the probability of stunting in this sample of rural Bangladeshi children.

2. Background

2.1. Empirical evidence linking women's empowerment to child nutrition

Overall, the relationships between maternal empowerment and child nutritional outcomes vary by context and by the dimension of empowerment studied (Sethuraman et al., 2006; Desai & Johnson, 2005; Cunningham, Ruel, Ferguson, & Uauy, 2015).

In many contexts, increased maternal empowerment is associated with lower rates of child stunting, wasting and underweight. Smith et al. (2003) test this relationship using data from 36 countries across three regions. They find a strongly significant and positive relationship between women's relative status and children's weight-for-age (*waz),* height-for-age (*haz)* and weight-for-height z-scores (*whz)* in South Asia and Sub-Saharan Africa. This study, however, relies on proxy indicators relating to employment, marriage, and human capital relative to her partner, to construct the independent variable, an index for women's relative decision-making power. Using these same proxies, Guha-Khasnobis and Hazarika (2007) find that in Pakistan children with more educated mothers relative to their fathers had better *haz* scores, and those whose mothers worked for cash income in the past year had better *whz* scores, a measure of short-term nutritional status. The age and education differential between the mother and her partner was

[1] The Women's Empowerment in Agriculture Index (WEAI) was jointly created, piloted and validated by The International Food Policy Research Institute and the Oxford Poverty and Human Development Initiative.

significant and negatively correlated with the share of household expenditure on three adult goods: tobacco, clothing, and footwear.

However, as noted in Guha-Khasnobis and Hazarika (2007), these proxy measures present possible endogeneity issues, since a woman's ability to work for cash income may be an outcome of her decision-making power in the home rather than a signal that she has improved her bargaining position in the household.

More recently, the literature has moved towards direct measures of women's empowerment, often across several dimensions, which has aided in the development of a more nuanced understanding of the relationship to child nutritional status. For example, Sethuraman et al., 2006 study a range of women's empowerment variables among rural and tribal women in Karnataka, finding that greater maternal mobility and decision-making power are associated with better child *waz* scores, after controlling for immediate and underlying causes of malnutrition, and that maternal experience of domestic violence is negatively associated with mothers' and children's nutritional status. Bhagowalia, Menon, Quisumbing, and Soundararajan (2012) ask which dimensions of women's empowerment matter the most for child nutrition, finding that in Bangladesh it is attitudes towards domestic violence, age at first marriage, and maternal height and education, that are significantly associated with child stunting.

Sraboni, Malapit, Quisumbing, and Ahmed (2014) use data from the first round of the Bangladesh Integrated Household Survey (BIHS) to investigate the role of women's empowerment (measured using WEAI) in contributing to household food security. They find that a greater empowerment score is associated with greater calorie availability and dietary diversity, and that the elasticities are largest with respect to women's rights to and ownership of assets.

In Nepal, Malapit, Kadiyala, Quisumbing, Cunningham, and Tyagi (2015) find that maternal control over income, group membership and workload were significantly and positively associated with her own dietary diversity and BMI, while control over income and the gender parity gap in the household influencing children's dietary diversity and *haz*. The study additionally investigates the interaction term between empowerment measures and production diversity, finding evidence that women's greater control of income can mitigate the negative effects of low production diversity on children's food security outcomes.

However, these studies are predominantly based on cross-sectional data, with the lack of longitudinal data ruling out the possibility of establishing causality, as noted by Cunningham, Ruel, et al. (2015) and Malhotra, Schuler and Boender (2002). To this end, our panel analysis, combined with its use of direct empowerment measures and child anthropometrics, constitutes a unique contribution to this topical area of research.

2.2. Defining and measuring empowerment

The many dimensions of women's status discussed so far – including women's control over resources, autonomy, decision-making abilities, self-esteem, and mental health – can be collectively described as aspects of women's *empowerment.* Empowerment has gained momentum as a key conceptual tool in recent empirical studies. It is most notably described in the literature as the process of expanding a person's ability to make strategic life choices, especially where this ability has been previously denied to them, within Kabeer's (1999) resources-agency-achievements framework of women's empowerment. Sraboni and Quisumbing (2018) find women's empowerment in agriculture to be positively associated with household calorie availability and dietary diversity in Bangladesh. This paper is in the spirit of this conceptualisation, particularly through its focus on whether women are able to translate various dimensions of empowerment in agriculture into strategic choices that influence their children's nutritional status.

As discussed above, we use the Women's Empowerment in Agriculture Index (WEAI), an innovative multidimensional empowerment index recently developed as part of a growing trend to quantify the concept of empowerment in a way that can be applied across contexts and across time. The WEAI was commissioned by the US Agency for International Development and was jointly created, piloted and validated by The International Food Policy Research Institute and the Oxford Poverty and Human Development Initiative. For a detailed description of survey design and sampling methods, see Alkire et al. (2013).

The focus of the WEAI index is on the relatively understudied 'agency' aspect of Kabeer's definition, and it seeks to assess the extent to which women are empowered in five domains of empowerment (5DE) in agriculture. These domains are: (i) decisions about agricultural production, (ii) access to and decision-making power about productive resources, (iii) control over use of income, (iv) leadership in the community, and (v) allocation of time.

Across these five domains, the WEAI collects data on 10 empowerment indicators, which can be used as an aggregate index or broken down into its sub-components. The WEAI also constructs an overall empowerment score (5DE, for the five dimensions of empowerment; $0 \leq 5DE\ score \leq 1$). Each of the five domains is given an equal weighting of 1/5. Within each domain, each indicator is weighted equally – so that control over income has a weight of 1/5, as it is the only indicator under Income, whereas ownership of assets is assigned a weight of 1/15, as there are three indicators under Resources. For each individual, the 5DE score reflects a weighted percentage of the indicators in which she is empowered. "Empowerment" within a domain means that the person has adequate achievements or has "achieved adequacy" for that domain.

Our empirical analysis focuses on the overall 5DE, and also on the individual components of the empowerment domains. These individual components include two women's empowerment measures from the production domain (input in productive decisions and autonomy in productive decisions), control over use of income, group membership and confidence speaking in public. The first three indicators relate to the hypothesis that women may tend to divert more of the household's income and/or food production towards children's nutritional needs when they are empowered to make these decisions for the household. The latter two variables – group membership and speaking in public – posit that women with more social capital and greater self-esteem are likely to have greater relative bargaining power in the household, which can be used to advocate on behalf of their own needs and the needs of their children. It is important to stress that although the WEAI is a quantitative index, it was conceptualised and validated based on qualitative case studies, and it is sensitive to differences in context and norms. The WEAI index used in this study was developed based on extensive survey and piloted in Bangladesh. Table 1 in the Appendix describes the variables used in the construction of the WEAI.

The two empowerment indicators under the production domain are related but distinct. Specifically, the variable input in productive decisions is constructed based on responses to questions "How much input did you have in making decisions about [farming, livestock and fishing activities]?", and whether the respondent has sole or joint input into decision-making with regards to farming, livestock and fishing, and whether she can have input into decisions on agricultural production, inputs and marketing, if she chooses to. According to Alkire et al. (2013), a respondent has "adequacy in this indicator if she participates and has at least some input in decisions or if someone else makes the decisions but the individual feels he or she could." They further state that there is no judgement in any of the empowerment indicators as to whether sole or joint decision-making conferred greater empowerment.

Table 1
Women's empowerment indicators in the WEAI.

Domain	Indicator	Empowered = 1 if the respondent:	Weight
Production	Input in productive decisions	Has some input in decision-making (either sole or jointly) with regards to farming, livestock and fisheries, or feels that she could be involved if she desired to	1/10
	Autonomy in production	Makes decisions about agricultural production principally motivated by her own values, rather than the disapproval or reactions of others	1/10
Resources	Ownership of assets	Has sole or joint ownership of at least one major asset	1/15
	Purchase, sale, or transfer of assets	Can participate in decisions to buy, sell, or transfer assets owned by the household	1/15
	Access to and decisions about credit	Belongs to a household that has access to credit, and if credit was used, participated in at least one decision about it	1/15
Income	Control over use of income	Has input into decisions about how to use income from activities she participated in	1/5
Leadership	Group membership	Is a member of at least one social or economic group	1/10
	Speaking in public	Feels comfortable speaking up in public about issues that matter to her, her family or community	1/10
Time	Workload	Worked no more than 10.5 h in the past 24 h	1/10
	Leisure	Is subjectively satisfied with the time available for leisure activities	1/10

Source: Adapted from Alkire et al. (2013).

The second variable in the production domain relates to autonomy in decision-making and is reflective of the respondent's ability to act on her values. To what extent do you feel you can make your own personal decisions regarding [farming, livestock and fishing] if you want(ed) to? "An individual is adequate on autonomy in production if her actions are relatively more motivated by his or her own values than by coercion or fear of others' disapproval." (Alkire et al., 2013).

The remaining indicators (resources and time) have been omitted from the main analysis because of concerns over whether they are likely to translate into real decision-making power in this context. Firstly, a woman's ownership or rights over assets may not necessarily indicate greater empowerment if she is unable to exercise these rights in a way that conflicts with the wishes of a male household member, due to social norms. The same concern applies to decisions regarding credit. Secondly, leisure time and workload may be more reflective of a household's overall situation than women's relative status within the household. This is supported by the fact that a similar proportion of men and women are disempowered in terms of time use. The results for these variables are available in the Appendix; overall the influence of these indicators was not significant in either direction.

2.3. Child anthropometrics as a measure of children's food security

The use of child anthropometric measures as an indicator of children's food security is in line with the *utilisation* definition of food security, under the Food and Agriculture Organization's four pillars of food security (FAO, 2006). For children to meet the anthropometric standards for growth, food production must be sufficient at the regional level to ensure adequate food supply is *available*, and children must belong to households with sufficient economic and physical resources to *access* these foods. Additionally, children in these households must be able to utilise these food resources to meet their nutritional requirements for growth, which requires adequate feeding and care practices, sanitation, dietary diversity, nutrient density, and a satisfactory level of short- and long-term health.

Child anthropometrics therefore capture a combination of food availability, access and utilization. The fourth dimension of food security, stability over time, will also play a role here given that instability can cause temporary disruptions in children's food intake, for example due to weather or food price shocks. These shocks affect children's nutrition in the short-term and can have a lasting impact on children's growth when they occur in the crucial first two to three years of life (Mendiratta, 2015).

The three major anthropometric measures – height-for-age, weight-for-age, and weight-for-height z-scores – reflect nutritional status over different durations. Underweight (weight-for-age) is determined by short-term energy balance and is therefore an indicator of acute undernutrition, while stunting (height-for-age) is determined by an inadequate energy balance over time and indicates chronic malnourishment. Wasting (weight-for-height), which combines both weight and height measurements, captures a combination of both acute and chronic undernutrition. All three measures are determined not only by food intake but a range of other biological and individual factors.

The main strength of child anthropometrics as a measure of food security is that it circumvents the problem of recall bias that affects other food security measures like dietary diversity, food consumption scores, and hunger coping strategies. They are also not affected by the possibility that surveyed households may change their consumption while under observation due to shame or embarrassment. Additionally, they capture multiple dimensions of food security simultaneously, as discussed above.

However, they are also subject to measurement error. The latent variable, children's food security, is inferred from these anthropometric measures. However, the relationship is also influenced by unobserved biological, individual, psychological and social factors. There is no direct mapping between children's nutritional intake and their anthropometry. This means that greater nutritional inputs on behalf of more empowered mothers do not directly translate to improvements in children's anthropometry. The relationship will also change over time, for example as children's total energy needs increase and as the potential for catch-up in terms of linear growth declines.

Nevertheless, the following analysis expects to capture, on average, the direction and significance of the relationships between the empowerment variables and child nutrition. As in other studies, this is done by controlling for age, gender and other observable characteristics that affect nutrition. In addition, unlike the majority of cross-sectional studies in this field, longitudinal data is used to better control for individual heterogeneity.

3. Data and methodology

This study draws on data from two waves of the *Bangladesh Integrated Household Survey* (BIHS), BIHS 2011–12 and BIHS 2015. The BIHS is a nationally representative survey that collects data from households in 325 randomly selected villages with probability proportional to their size. The sample is designed to be statistically representative of rural Bangladesh at the national level, and at the level of each of the nation's seven administrative divisions. The survey includes comprehensive plot-level agricultural data along with dietary intake of household members, anthropometric measurements of all household members including children, mothers' nutrition knowledge and practices, and a module of survey questions to construct the Women's Empowerment in Agriculture Index (WEAI) (see Alkire et al., 2013).

Since child anthropometrics is our outcome variable, the sample is restricted to households with children aged 6–59 months. Excluding children under 6 months is common in nutritional surveys, due to practical and technical difficulties in measuring newborns and young infants (Lopriore, Dop, Solal-Céligny, & Lagnado, 2007, p.1). It is also consistent with the purpose of this analysis, which focuses on anthropometrics as a measure of children's food security, since children below 6 months would not have begun complementary feeding.

For the purposes of this paper, each model is estimated for observations with WEAI information for the indicator used. This restricts the estimation sample to children from households with a primary female respondent involved in agriculture. This leaves a final sample of 1717 children in 2011 and 1886 children in 2015, for the pooled cross-sectional analysis. The longitudinal nature of the data is then utilised to conduct a panel analysis of the 468 children in this sample who were observed in both rounds of the survey.

3.1. Dependent variables

Our outcome variables are child anthropometric measures which serve as indicators of the latent variable, children's food security.

Both continuous and discrete measures of children's nutritional status are considered. Discrete measures are children's height-for-age, weight-for-age, and weight-for-height z-scores which are defined in comparison to a comparable healthy reference population. The corresponding discrete measures are stunting, wasting and underweight – defined as *haz, waz* and *whz* scores of more than two standard deviations below the mean, respectively, in line with cut-offs set by the WHO Global Database on Child Growth and Malnutrition.

3.2. Independent variables

The main independent variables in this analysis are five key indicators from the production, income and leadership domains of the WEAI: women's input in productive decisions, autonomy in productive decisions, control over use of income, group membership and speaking in public. Each of the indicators is expressed in the form of a binary variable (=1 if the individual is empowered, defined as having adequate achievements in 80 per cent or more of the survey questions for that indicator, = 0 otherwise). Women's overall 5DE score, constructed as an index from all ten indicators, is also examined.

To begin with, each indicator is included in the models one at a time, in order to prevent collinearity between the variables from affecting the significance and direction of the results. This is likely to occur when including or aggregating multiple empowerment variables that would each be expected to translate to women's status in the home and to children's food security in distinct and complex ways (Malhotra, Schuler & Boender 2002).

Since we are interested in the influence of maternal empowerment on child nutrition, we also include a measure of household dietary diversity. This measure includes the number of food groups consumed by at least one member of the household in the past 7 days out of a total of 10 groups (cereals, tubers, vegetables, fruits, meat, eggs, fish, beans/nuts/pulses, dairy, and oils/sugar/condiments), is included as an explanatory variable. This is done to examine the influence of women's empowerment on child nutrition outcomes holding constant the household's access to a variety of foods. Variation in child nutrition outcomes will then reflect whether households where women are more empowered divert a greater portion of the food and crop resources at the household's disposal towards young children's nutritional needs, rather than capturing in part variations in the households' overall food security.

Bangladeshi married women had the highest prevalence of intimate partner violence among South Asian countries with a DHS violence module (Solotaroff & Pande, 2014). Therefore, domestic violence is included as an indicator variable to capture an additional dimension of women's status and bargaining power in the home. The variable is equal to 1 if women report having experienced physical or verbal abuse at the hands of their husband or in-laws, or if their husband has threatened them with divorce or with taking a new wife, in the past 12 months.

Variables controlling for mother's nutritional knowledge such as appropriate breastfeeding, complementary food and liquids practices, purchase of supplements, and familiarity with iron deficiency symptoms were initially examined but excluded from the final regressions due to (1) a large number of missing observations, with this nutrition data available for less than half of the sample, and (2) the possibility that, as empowered mothers may be better able to provide good nutrition to their children, correlation between the empowerment variables and the nutritional control variables could lead to a less precise estimate of the independent effect of empowerment on child nutrition, given that some of this effect is 'captured' by the nutrition knowledge variables.[2]

The remaining explanatory variables are control variables, which are vectors of individual, household and community-level characteristics reported in Tables 2 and 3.

3.3. Empirical strategy

The aim of this analysis is to empirically determine how dimensions of women's empowerment influence children's nutritional outcomes among households in rural Bangladesh. It aims to (a) identify the direction and significance of the effects of five key empowerment variables on children's nutritional outcomes, (b) exploit the panel nature of the data to allow for heterogeneity across individuals, and (c) examine whether child gender factors into these relationships. Ultimately this analysis will provide a more precise understanding of which dimensions of women's empowerment are associated with children's food security in this setting.

Key identification issues in this analysis are the role of unobserved heterogeneity in studies of nutritional outcomes, and the potential endogeneity of women's empowerment variables. These issues are addressed alongside the empirical estimation strategies described below.

To identify the effects of the empowerment variables on nutritional outcomes, three main models are estimated: (1) a pooled Ordinary least squares (OLS) model to utilise the full sample of observations and to estimate the effects of time-invariant characteristics such as gender, (2) panel fixed- and random-effects models to allow for the likelihood of individual-level effects, concluding on the latter, and (3) Probit models to investigate the influence of empowerment on the probability of the binary outcome: that children are malnourished. In addition, instrumental variable techniques were tried to control for potential endogeneity of the empowerment variables, and the resulting models tested to determine whether these variables are indeed endogenous.

3.4. Pooled OLS

In the initial pooled OLS regressions, the continuous variables for child nutrition – *haz, waz* or *whz* – are modelled as a function

[2] For more in-depth analyses of the relationships between women's empowerment and nutritional knowledge and practices, see for example Na, Jennings, Talegawkar, and Ahmed (2015)

Table 2
Descriptive statistics.

	Year = 2011 [N = 1717]		Year = 2015 [1886]	
Child's age (months)	31.31	(15.2)	33.03	(15.3)
Child's gender = male	0.50		0.53	
Length/height-for-age Z-score	−1.89	(1.33)	−1.69	(1.22)
Weight-for-age Z-score	−1.58	(1.01)	−1.62	(1.01)
Weight-for-length/height Z-score	−0.75	(1.13)	−0.96	(1.15)
Stunting				
Low ($haz \leq -1$)	0.79		0.75	
Moderate ($haz \leq -2$)	0.50		0.41	
Severe ($haz \leq -3$)	0.19		0.13	
Underweight				
Low ($waz \leq -1$)	0.73		0.75	
Moderate ($waz \leq -2$)	0.34		0.36	
Severe ($waz \leq -3$)	0.08		0.08	
Wasting				
Low ($whz \leq -1$)	0.39		0.48	
Moderate ($whz \leq -2$)	0.11		0.17	
Severe ($whz \leq -3$)	0.03		0.04	
WEAI variables				
Input in productive decisions, women	0.61		0.91	
Control over use of income, women	0.75		0.86	
Autonomy in production, women	0.85		0.79	
Ownership of asset, women	0.75		0.87	
Access to and decision on credit, women	0.51		0.53	
Speaking in Public, women	0.32		0.58	
Group member, women	0.29		0.24	
Leisure, women	0.71		0.72	
Workload, women	0.75		0.76	
Purchase, sale or transfer of asset, women	0.61		0.52	
5DE score, women	0.62		0.69	
Household Characteristics				
Land, total (hectares)	77.92	(136.0)	89.78	(166.7)
Ln(total land + 1)	2.830	(2.17)	3.44	(1.59)
Household has electricity	0.44		0.58	
Water piped or from tube well	0.67		0.61	
Sealed toilet or latrine	0.74		0.87	
No. members under 15	2.33	(1.16)	2.31	(1.02)
No. working age members	2.43	(1.10)	2.56	(1.26)
No. members over 65	0.18	(0.43)	0.18	(0.42)
Child has one or more siblings under 6	0.35		0.37	
Hh head is literate	0.50		0.55	
Hh head is male	0.87		0.83	
Hh head edu, higher secondary or above	0.03	(0.18)	0.030	(0.18)
Dietary Diversity Score (10 food groups)	7.32	(1.56)	8.270	(1.35)
Division = Barisal	0.076		0.700	
Division = Chittagong	0.168		0.190	
Division = Dhaka	0.308		0.313	
Division = Khulna	0.078		0.075	
Division = Rajshahi	0.108		0.086	
Division = Rangpur	0.110		0.096	
Division = Sylhet	0.153		0.170	
Domestic abuse (=1 if physical abuse, verbal abuse or threatened divorce in the last 12 months)	0.33		0.43	
Age difference between primary male and female	7.68	(4.69)	7.62	(4.63)

Note: The figures represent sample means for continuous variables and proportions for discrete variables. Standard deviations appear in parentheses for continuous variables. Summary statistics are displayed for the model with the largest estimated sample (group membership).

of female empowerment and vectors of individual, household and community/village-level characteristics:

$$\boldsymbol{c} = b_0 + b_1\ empowerment + b_2\boldsymbol{I} + b_3\boldsymbol{H} + b_4\boldsymbol{C} + \varepsilon \quad (1)$$

The coefficient b_1 in each of the regressions show the effect of each empowerment variable on children's *haz, waz,* or *whz* scores under the assumptions that the intercept and slope coefficients are constant across individuals. To address the potential for serial correlation, standard errors are clustered at the village-level.

In addition to this main estimation, an interaction term for empowerment and child gender is added according to the equation:

$$\boldsymbol{c} = b_0 + b_1\ empowerment + b_2(empowerment \times femalechild) + b_3\boldsymbol{I} + b_4\boldsymbol{H} + b_5\boldsymbol{C} + \varepsilon \quad (2)$$

This will test whether empowerment affects girls and boys' outcomes differently. If b_2 is significantly greater than zero, this indicates women's empowerment has a greater effect on girls' nutrition compared to boys.

3.5. Panel random-effects

However, the assumptions of pooled OLS may be too restrictive, due to the likelihood of heteroscedasticity across individual units. Therefore, we explore panel fixed- and random-effects models to allow for individual-level effects. These are likely to play a large role, as many variables that influence nutrition – prenatal development, genetic factors, the history, nature and duration of illnesses, the gut microbiome – are unique to individuals and are difficult to observe and measure.

Table 3
Panel Sample Characteristics.

	Year = 2011		Year = 2015	
No. of observations	402		454	
	Mean or %		Mean or %	
Child variables				
Child's age (months)	12.87	(4.35)	51.43	(4.39)
Child's age squared (months)	184.5	(120.1)	2664	(442.7)
Child's gender = male	0.50		0.51	
Length/height-for-age Z-score	−1.72	(1.40)	−1.73	(0.99)
Weight-for-age Z-score	−1.39	(1.09)	−1.76	(0.86)
Weight-for-length/height Z-score	−0.67	(1.26)	−1.08	(1.03)
Stunting				
Low ($haz \leq -1$)	0.75		0.78	
Moderate ($haz \leq -2$)	0.44		0.37	
Severe ($haz \leq -3$)	0.17		0.11	
Underweight				
Low ($waz \leq -1$)	0.64		0.83	
Moderate ($waz \leq -2$)	0.29		0.38	
Severe ($waz \leq -3$)	0.07		0.09	
Wasting				
Low ($whz \leq -1$)	0.38		0.53	
Moderate ($whz \leq -2$)	0.11		0.16	
Severe ($whz \leq -3$)	0.04		0.04	
WEAI variables				
Input in productive decisions, women	0.57		0.91	
Control over use of income, women	0.72		0.86	
Autonomy in production, women	0.85		0.76	
Ownership of asset, women	0.75		0.88	
Purchase, sale or transfer of asset, women	0.60		0.54	
Access to and decision on credit, women	0.51		0.54	
Speaking in Public, women	0.29		0.61	
Group member, women	0.27		0.22	
Leisure, women	0.72		0.73	
Workload, women	0.75		0.78	
5DE score, women	0.61		0.69	
Household Characteristics				
Land, total (hectares)	83.19	(151.2)	84.72	(162.4)
Ln(total land + 1)	2.91	(2.17)	3.39	(1.57)
Household has electricity	0.44		0.59	
Water piped or from tube well	0.66		0.59	
Sealed toilet or latrine	0.75		0.86	
No. members under 15	2.22	(1.12)	2.29	(0.95)
No. working age members	2.37	(0.92)	2.38	(1.08)
No. members over 65	0.17	(0.41)	0.16	(0.39)
Child has one or more siblings under 6	0.37		0.32	
Household head is literate	0.49		0.53	
Household head is male	0.90		0.84	
Household head education, higher secondary or above	0.04		0.02	
Dietary Diversity Score (10 food groups)	7.29	(1.53)	8.14	(1.36)
Division = Barisal	0.077		0.075	
Division = Chittagong	0.182		0.205	
Division = Dhaka	0.291		0.295	
Division = Khulna	0.010		0.088	
Division = Rajshahi	0.114		0.097	
Division = Rangpur	0.095		0.084	
Division = Sylhet	0.142		0.156	
Domestic abuse (=1 if physical abuse, verbal abuse or threatened divorce in the last 12 months)	0.32		0.49	
Age difference between primary male and female	7.42	(4.63)	7.32	(4.50)

Note: Standard deviations appear in parentheses for continuous variables. Summary statistics are displayed for the model with the largest estimated sample (group membership).

The adoption of a fixed- or random-effects model allows for each individuals' intercept to vary across individuals and possibly time. For each observation,

$$c_{it} = \boldsymbol{x}_{it}\boldsymbol{b}_k + \boldsymbol{z}_i\boldsymbol{\delta} + u_i + \epsilon_{it} \quad (3)$$

where c_{it} is the child's *z*-score for *haz, waz* or *whz*; $\boldsymbol{x}_{it}$ is a vector of explanatory variables that vary across individuals and over time; $\boldsymbol{b}_k$ are the corresponding slope coefficients (assumed to be constant across individuals and time), $\boldsymbol{z}_i$ is a vector of variables that vary across individuals but are constant over time, such as gender, and $\boldsymbol{\delta}$ is the corresponding vector of slope coefficients, u_i is the child's individual-level effect and ϵ_{it} is a random disturbance term.

In a random-effects model the individual error terms u_i are assumed to be uncorrelated with the explanatory variables included in $\boldsymbol{x}_{it}$ and $\boldsymbol{z}_i$, while a fixed-effects model allows u_i to be correlated with the regressors. The appropriateness of a random-effects model is tested using a Hausman test of the null hypothesis that the random-effects estimator is consistent. The null is not rejected for each of the models, and therefore the random-effects

model is chosen given its efficiency advantage over a fixed-effects model. The random-effects model also has the advantage of allowing for inferences about the population from which the sample is drawn.

3.6. Probit marginal effects

Given the prevalence and particularly high costs of stunting in Bangladesh, policy makers with an interest in reducing stunting may be more interested in studying the role of empowerment in predicting the binary outcome, whether a child is stunted (=1 if $haz \leq -2$, = 0 otherwise).

The results, presented in terms of marginal effects, will capture the instantaneous effect of a change from 0 (disempowered) to 1 (empowered) on the probability that a child's z-score falls more than two standard deviations below the mean, holding all other explanatory variables fixed at their means.

3.7. Instrumental variable (IV) estimation

Previous studies have raised concerns over the potential endogeneity of female empowerment variables, since even direct measures of empowerment are likely to be correlated with unobserved variables that also affect child nutrition (Lépine & Strobl, 2012). For example, empowered women may have husbands or in-laws who have an unobserved preference for more educated wives. This preference for education may also lead these households to make greater human capital investments in their children, and so affect child nutrition outcomes. Alternatively, as pointed out by Lépine & Strobl, 2012, empowered women may belong to households where decision-making falls to the wife because the husband is more disengaged. This could lead to an under-estimation of the effect of empowerment in agriculture on child nutrition, since female empowerment is confounded by low effort on the part of her husband.

To account for potential endogeneity of the female empowerment variables, we investigated several instruments that are identified in previous literature as likely to affect children's nutritional outcomes only through their effect on women's empowerment. Following Sraboni et al. (2014) we include as instruments the following variables- age difference between the primary male and female, and the log of the value of the wife's assets brought to marriage. These are likely to be correlated with the empowerment variables through their influence on women's bargaining power in the home. However, as they were determined in a previous period, they may have little direct impact on child nutrition outcomes in the current period. The number of informal credit sources and the number of community organizations in the village were also tried as instruments for women's access to and decisions over credit and group membership, respectively, as they are expected to be highly correlated with these empowerment variables but not necessarily with the error term. However these instruments ultimately could not be tested due to gaps in the available community-level data.

If the empowerment indicators are indeed endogenous in this model, failing to account for this endogeneity may lead to an over- or under-estimation of the effects of women's empowerment on child nutritional outcomes. To examine the potential endogeneity of the indicators, standard instrumental variable techniques were tried using variables that are expected to be uncorrelated with the error term but highly correlated with the empowerment variables. The instruments chosen include the age difference between the primary male and female in the household, which has been shown to be highly correlated with women's decision-making power in the home (Smith et al., 2003). It may also satisfy the exclusion restriction if it influences child nutrition only through its influence on women's relative bargaining power in the home, and so is worth investigating. The log of wife's assets brought to marriage was also examined, for the same reason. Over- and under-identification tests for these instruments support the suitability of male-female age difference as an instrument. The Kleibergen-Paap rk LM statistic for wife's assets brought to marriage indicates that the models are under-identified, and the results show the instrument is not significantly correlated with the empowerment indicators in the first stage. It therefore fails to satisfy the relevance condition.

Given that IV estimation implies a loss of efficiency that needs to be balanced against potential bias and inconsistency of the OLS estimates if the empowerment variables are indeed correlated with the error term, Durban-Wu-Hausman tests were undertaken to determine if the empowerment variables should indeed be treated as endogenous. In our specifications the Hausman test statistics did not reject the exogeneity of any of the empowerment variables at 5 percent. Additionally, the Stock-Yogo critical values indicate the models fail to limit the bias of the standard errors to 25 per cent of the pooled OLS estimates. It was therefore decided that the efficiency cost of IV estimation may not be worth the gains in consistency, particularly given that the exogeneity of the empowerment variables is not rejected at the 10 per cent level in these models (Cameron & Trivedi, 2005, Chapter 4). Therefore, in the absence of better instruments, the main results are presented for OLS over IV, as in previous studies such as Sraboni et al. (2014).

4. Results

4.1. Descriptive statistics

The characteristics of the pooled cross-sectional sample and the panel sample are shown in Tables 2 and 3, respectively. Particularly high rates of stunting are observed, with almost half the children under 5 classified as being stunted (z-score ≤ -2) in 2011. This proportion falls by 9 per cent in the follow-up survey. Underweight (33 per cent) and wasting (12 per cent) are also prevalent in 2011; proportions which rise in 2015. However, for these short-term nutritional indicators, the rise may reflect in part a seasonality effect. These child malnourishment figures are in line with those reported in other demographic surveys of Bangladesh (Hussain et al., 2015; Das & Gulshan, 2017).

At baseline, the mean overall empowerment score in the five dimensions of the WEAI (5DE score) was 0.624. The proportion of women who were empowered in its individual indicators ranged from 29 to 85 per cent of the sample; few women had adequate achievements in terms of group membership and the confidence to speak up in public, while three-quarters or more were empowered in terms of control over use of income, autonomy in productive decisions, asset ownership and workload.

Notably, significant changes are observed in many of the WEAI variables between 2011 and 2015 – often more than might be expected over a four-year time period. We see an improvement in some measures of female empowerment in the WEAI index and a small increase in the overall 5DE (5 domains of empowerment). However, some measures of the WEAI have actually worsened over the study period (eg. Purchase, sale or transfer of assets; group membership; autonomy in production decisions). Independent samples t-tests for the hypothesis that the average proportion of women empowered in each domain did not change between the two years were strongly rejected for all of the variables except decisions over credit, leisure time and workload. This conclusion holds when restricted to households that appear in both survey years. This suggests there may be other factors influ-

encing changes over time in the WEAI variables, for example being familiar with the question at follow-up leading respondents to interpret or answer the question differently. This possibility is discussed in further detail following the results of the panel analysis.

Additionally, in 2011, almost 33 per cent of the sample women reported experiencing at least one form of domestic abuse in the past year; this rises significantly to 42 per cent in 2015. This may reflect an actual rise in the incidence of domestic abuse between the two years, or that more of the surveyed women feel comfortable reporting these incidents in the follow-up round (or some combination of the two factors).

Table 3 summarises the characteristics of the panel sample. Children included in the panel are those aged between 6 and 59 months in 2011, who are observed again in 2015. As a result, the panel sample has a mean age of 12.9 months in 2011 and 51.4 months in 2015. When comparing changes in the incidence of stunting between the two years, we are also observing age effects that will be addressed in later regressions. In many developing countries, the prevalence of stunting tends to increase with age between 6 and 24 months, and then decline as children grow older (WHO, 1997 p. 46). One limitation of a panel study in this context is that stunting is regarded as a long-term measure, in that it is mostly determined in the first two to three years of life. Over a longer period, stunting reflects "having failed to grow" (WHO, 1997 p. 47) in this crucial period. Therefore the potential for women's empowerment to improve stunting outcomes over the duration of this study is greatest in the first 12 months or so after the first survey, and we expect a gradual decline over time.

The results from the empirical estimations are presented in Tables 4–7. Table 4 describes the results from the pooled OLS for children's *haz, whz* and *waz* scores using women's overall 5DE score as the explanatory variable for empowerment. Table 5 displays the results when the model is estimated using each of the five selected empowerment indicators separately, using children's *haz* scores as the dependent variable. Table 6 shows the results from a panel random-effects model and Table 7 presents the marginal effects from the Probit model.

The main findings of the analyses are as follows: (1) haz is statistically significant and positively associated with overall 5DE score, (2) when we included individual empowerment measures, only women's autonomy in productive decisions and confidence speaking in public are positively and significantly associated with children's *haz* scores in the pooled OLS model, and negatively and significantly associated with the probability of stunting in the Probit model. Finally, (3) all the empowerment measures (including the 5DE) are significantly associated with greater household dietary diversity.

Each model has been estimated for all three nutritional indicators, however this paper will focus on stunting outcomes (*haz*) as the preferred measure of children's nutritional status given the lag in survey months between the two years[3]. This introduces a seasonality effect that may confound the relationship between the explanatory variables and short-term nutritional indicators, children's *waz* and *whz* scores. The results for the remaining empowerment indicators are presented in the Appendix; overall, these indicators were not significantly associated with nutritional outcomes in either direction.

[3] The 2011 survey was conducted between November and March, whereas the 2015 survey was conducted between January and May. The data collection periods thus differ in their proximity to monsoon season and harvest period. This impacts on children's short-term nutritional status given that many households experience significant seasonal variation in monsoon vs. dry-season per capita calorie availability (Hillbruner & Egan, 2003).

Table 4
Pooled OLS estimates: Dependent variables (*haz, waz, whz*).

	Dependent variables		
	(1)	(2)	(3)
VARIABLES	haz	waz	whz
Overall 5DE score, women	0.268**	−0.005	−0.235**
	[0.129]	[0.108]	[0.115]
Child's age (months)	−0.059***	−0.029***	−0.002
	[0.007]	[0.006]	[0.006]
Child's age squared (months)	0.001***	0.000***	−0.000
	[0.000]	[0.000]	[0.000]
Child's gender = male	−0.111**	0.011	0.039
	[0.044]	[0.035]	[0.043]
Division dummies	Yes	Yes	Yes
Year 2 (2015)	0.134***	−0.108***	−0.256***
	[0.043]	[0.032]	[0.042]
Ln(total land + 1)	0.045***	0.044***	0.026**
	[0.015]	[0.011]	[0.012]
Household has electricity	0.071	0.064*	0.030
	[0.049]	[0.039]	[0.049]
Water piped or from tube well	0.091*	0.041	−0.016
	[0.052]	[0.041]	[0.051]
Sealed toilet or latrine	0.000	0.094**	0.118**
	[0.058]	[0.044]	[0.051]
Child has one or more siblings under 6 years old	−0.114**	−0.038	0.034
	[0.053]	[0.042]	[0.047]
No. members under 15	−0.040	−0.030	−0.005
	[0.025]	[0.020]	[0.021]
No. working age members	0.010	0.005	−0.002
	[0.022]	[0.018]	[0.019]
No. members over 65	0.041	0.057	0.051
	[0.052]	[0.047]	[0.056]
Household head is male	−0.095	−0.207***	−0.234***
	[0.067]	[0.059]	[0.068]
Household head is literate	0.099*	0.045	−0.015
	[0.052]	[0.040]	[0.044]
Household head education, higher secondary or above	0.504***	0.356***	0.116
	[0.141]	[0.107]	[0.119]
Dietary Diversity Score (10 food groups)	0.030*	0.043***	0.038**
	[0.016]	[0.012]	[0.015]
Domestic abuse	−0.085**	−0.104***	−0.071*
	[0.041]	[0.034]	[0.039]
Constant	−1.417***	−1.311***	−0.619***
	[0.201]	[0.160]	[0.191]
Observations	3603	3603	3603
R-squared	0.072	0.077	0.033

Robust standard errors in brackets, clustered at the village level. ***p < 0.01, **p < 0.05, *p < 0.1.

4.2. Pooled OLS

From Table 4, we observe that the overall empowerment score of women is positively and significantly associated with improved children's *haz* scores. In other words, children whose mothers are more empowered have higher *haz* scores. As expected, the size of the household's land, access to clean water, the education of the household head and the household's dietary diversity are also statistically significant and positively associated with a child's long-term nutritional status. The dummy variable for 2015 is also statistically significant, indicating an improvement in stunting among young children in these households between 2011 and 2015.

On the other hand, contrary to expectations, boys have significantly lower *haz* scores. This is contrary to the expectation that young boys will be favoured over girls in the allocation of nutritious foods. Yet this is in line with other studies from Bangladesh (Islam et al., 2019; Islam et al., 2018) and Wamani, Åstrøm, Peterson, Tumwine, and Tylleskär (2007) meta-analysis also finds boys under five to be at a higher risk of stunting than girls in Sub-Saharan Africa. This may be explained by the finding that mor-

Table 5
Effect of women's empowerment indicators on children's *haz* scores, 6–59 months: OLS estimates.

	Dependent variable: Children's *haz* scores				
VARIABLES	(1) Input in productive decisions	(2) Autonomy in production	(3) Control over use of income	(4) Speaking in Public	(5) Group membership
Empowerment variables					
Input in productive decisions	0.085				
	[0.054]				
Autonomy in production		0.191***			
		[0.054]			
Control over use of income			−0.022		
			[0.058]		
Speaking in public				0.170***	
				[0.042]	
Group membership					0.024
					[0.048]
Child variables					
Child's age (months)	−0.055***	−0.059***	−0.059***	−0.058***	−0.059***
	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]
Child's age squared (months)	0.001***	0.001***	0.001***	0.001***	0.001***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Child's gender = male	−0.110**	−0.108**	−0.114**	−0.109**	−0.111**
	[0.045]	[0.044]	[0.044]	[0.044]	[0.044]
Household characteristics					
Year 2 (2015)	0.108**	0.162***	0.146***	0.110**	0.146***
	[0.047]	[0.043]	[0.043]	[0.043]	[0.042]
Division dummies	Yes	Yes	Yes	Yes	Yes
Ln(total land + 1)	0.049***	0.047***	0.051***	0.046***	0.049***
	[0.015]	[0.014]	[0.015]	[0.014]	[0.014]
Household has electricity	0.051	0.084*	0.072	0.059	0.076
	[0.051]	[0.049]	[0.049]	[0.050]	[0.049]
Water piped or from tube well	0.088	0.086	0.088*	0.094*	0.087*
	[0.054]	[0.053]	[0.052]	[0.052]	[0.052]
Sealed toilet or latrine	0.036	−0.002	−0.001	0.018	−0.000
	[0.061]	[0.058]	[0.057]	[0.058]	[0.058]
Child has one or more siblings under 6 years old	−0.106*	−0.130**	−0.119**	−0.116**	−0.121**
	[0.056]	[0.053]	[0.053]	[0.052]	[0.053]
No. members under 15	−0.037	−0.033	−0.038	−0.040	−0.038
	[0.026]	[0.025]	[0.025]	[0.025]	[0.025]
No. working age members	0.011	0.008	0.009	0.011	0.009
	[0.022]	[0.022]	[0.022]	[0.022]	[0.022]
No. members over 65	0.026	0.036	0.034	0.041	0.035
	[0.053]	[0.052]	[0.051]	[0.051]	[0.051]
Household head is male	−0.109	−0.074	−0.103	−0.080	−0.100
	[0.069]	[0.068]	[0.067]	[0.066]	[0.067]
Household head is literate	0.086	0.105**	0.101*	0.099*	0.101*
	[0.053]	[0.053]	[0.052]	[0.052]	[0.052]
Household head education, higher secondary or above	0.494***	0.478***	0.500***	0.480***	0.496***
	[0.148]	[0.142]	[0.142]	[0.141]	[0.141]
Dietary Diversity Score (10 food groups)	0.034**	0.032**	0.033**	0.031**	0.032**
	[0.017]	[0.016]	[0.016]	[0.016]	[0.016]
Domestic abuse	−0.084*	−0.088**	−0.092**	−0.094**	−0.088**
	[0.043]	[0.041]	[0.041]	[0.041]	[0.041]
Constant	−1.422***	−1.381***	−1.241***	−1.345***	−1.268***
	[0.204]	[0.197]	[0.192]	[0.188]	[0.189]
Observations	3343	3538	3596	3578	3603

Robust standard errors in brackets, clustered at the village level.
***p < 0.01, **p < 0.05, *p < 0.1.

bidity and mortality rates tend to be higher for males in early life, and they have on average an increased demand for nutrients due to differences in their growth trajectories (Islam et al., 2018).

Interestingly, children in households where the household head is male have significantly lower *waz* and *whz* scores, and the negative association holds even when controlling for other household characteristics. This variable is however not statistically significant for the long-term measure *haz*, our main variable of interest. It is possible that females in male-headed households may have their decision-making ability compromised.[4] Additionally, our summary statistics for children disaggregated by male headed versus female headed households show that children in female headed households have on average better *haz, waz* and *whz* and these differences are statistically significant. Literacy rates are also higher among female headed households 66% vs 50% in male headed households (Table A1 in the Appendix).

Women's experience of domestic abuse is statistically significant and negatively associated with all three nutritional indicators. Domestic violence on its own is an indicator of empowerment, and represents an important aspect of the relationship between empowerment and child nutrition, particularly given its high incidence – affecting over a third of the women in this sample.

[4] We are grateful to an anonymous Reviewer for pointing to this possibility.

Table 6
Panel random-effects model of children's *haz* scores.

	Dependent variable: Children's *haz* scores					
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES						
Empowerment variables						
Overall 5DE score	0.128					
	[0.218]					
Input in productive decisions		0.033				
		[0.104]				
Autonomy in production			0.152			
			[0.096]			
Control over use of income				−0.125		
				[0.103]		
Speaking in public					0.058	
					[0.079]	
Group membership						−0.076
						[0.090]
Child variables						
Child's age (months)	−0.096***	−0.094***	−0.097***	−0.094***	−0.096***	−0.094***
	[0.022]	[0.022]	[0.023]	[0.022]	[0.022]	[0.022]
Child's age squared (months)	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Household characteristics						
Year 2 (2015)	1.587***	1.563***	1.591***	1.585***	1.557***	1.591***
	[0.481]	[0.527]	[0.491]	[0.481]	[0.480]	[0.480]
Ln(total land + 1)	0.045*	0.049*	0.049*	0.052**	0.047*	0.047*
	[0.025]	[0.026]	[0.026]	[0.025]	[0.025]	[0.025]
Household has electricity	0.076	0.089	0.092	0.074	0.079	0.078
	[0.090]	[0.095]	[0.091]	[0.090]	[0.091]	[0.090]
Water piped or from tube well	0.013	0.039	0.009	0.012	0.013	0.008
	[0.086]	[0.093]	[0.087]	[0.086]	[0.087]	[0.087]
Sealed toilet or latrine	−0.050	−0.028	−0.048	−0.052	−0.053	−0.045
	[0.105]	[0.113]	[0.106]	[0.105]	[0.106]	[0.106]
Child has one or more siblings under 6 years old	−0.085	−0.077	−0.091	−0.079	−0.085	−0.080
	[0.094]	[0.100]	[0.095]	[0.094]	[0.095]	[0.094]
No. members under 15	−0.012	−0.005	−0.012	−0.015	−0.011	−0.013
	[0.050]	[0.052]	[0.050]	[0.050]	[0.050]	[0.050]
No. working age members	0.052	0.052	0.049	0.045	0.052	0.050
	[0.044]	[0.045]	[0.044]	[0.044]	[0.044]	[0.044]
No. members over 65	0.162	0.128	0.168	0.150	0.153	0.163
	[0.103]	[0.104]	[0.106]	[0.103]	[0.103]	[0.103]
Household head is male	0.006	0.017	0.002	0.025	0.014	0.011
	[0.140]	[0.162]	[0.141]	[0.142]	[0.138]	[0.139]
Household head is literate	−0.030	−0.056	−0.031	−0.024	−0.031	−0.033
	[0.099]	[0.107]	[0.101]	[0.101]	[0.100]	[0.099]
Household head education, higher secondary or above	0.680**	0.698**	0.658**	0.710**	0.679**	0.693**
	[0.285]	[0.286]	[0.289]	[0.286]	[0.285]	[0.289]
Dietary Diversity Score (10 food groups)	0.036	0.041	0.045	0.038	0.038	0.038
	[0.030]	[0.032]	[0.031]	[0.030]	[0.031]	[0.030]
Domestic abuse	−0.017	−0.011	−0.021	−0.018	−0.022	−0.007
	[0.083]	[0.087]	[0.083]	[0.082]	[0.083]	[0.082]
Constant	−1.219***	−1.276***	−1.318***	−1.098***	−1.176***	−1.153***
	[0.353]	[0.354]	[0.354]	[0.343]	[0.340]	[0.339]
Observations	856	796	838	854	849	856
Number of groups	468	450	465	467	468	468

Robust standard errors in brackets, clustered at the village level. ***p < 0.01, **p < 0.05, *p < 0.1.

Empowerment has been associated with lower incidence of spousal violence in many contexts, for example Donta et al. (2015), but can have the unintended consequence of exposing women to an increased risk of violence in others (Rocca et al., 2009); including in culturally conservative areas of Bangladesh (Koenig, Ahmed, Hossain, & Mozumder, 2003). In both cases domestic violence disempowers women, and in this sample is associated with significantly worsened child nutrition outcomes. Working to eliminate domestic violence is therefore expected to have a positive impact on child nutrition in Bangladesh.

Table 5 shows the results when the model is estimated for the influence of individual empowerment variables separately, on children's *haz* scores. From Table 5 we observe that autonomy in the household's production decisions is positively and significantly associated with *haz* scores. This is consistent with the hypothesis that when women are empowered to make decisions autonomously about home food production, cash crop production, and livestock raising (such as the type of crops to produce and how much of them to sell in the market) they may make these decisions in a way that favours the nutritional needs of young children in the household, compared to when these decisions are out of their hands or motivated by the preferences of their spouse or community. These findings are supported by Cunningham et al. (2015) study from Nepal where the autonomy in production variable from the WEAI was found to be statistically significant and positively associated with better *haz* among children.

Table 7
Probit model- child stunting (haz ≤ – 2), full sample of children 6–59 months.

	Dependent variable: Child is stunted (*haz* ≤ – *2*)				
VARIABLES	(1) Input in productive decisions	(2) Autonomy in production	(3) Control over use of income	(4) Speaking in Public	(5) Group membership
Empowerment variables					
Input in productive decisions	−0.035				
	[0.023]				
Autonomy in production		−0.041*			
		[0.022]			
Control over use of income			0.018		
			[0.024]		
Speaking in public				−0.046***	
				[0.017]	
Group membership					−0.013
					[0.020]
Child variables					
Child's age (months)	0.021***	0.022***	0.022***	0.022***	0.022***
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Child's age squared (months)	−0.000***	−0.000***	−0.000***	−0.000***	−0.000***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Child's gender = male	0.050***	0.047***	0.048***	0.049***	0.047***
	[0.019]	[0.018]	[0.018]	[0.018]	[0.018]
Household characteristics					
Division dummies	Yes	Yes	Yes	Yes	Yes
Year 2 (2015)	−0.046**	−0.077***	−0.070***	−0.062***	−0.070***
	[0.020]	[0.019]	[0.019]	[0.019]	[0.018]
Ln(total land + 1)	−0.019***	−0.018***	−0.019***	−0.018***	−0.019***
	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]
Household has electricity	−0.019	−0.029	−0.025	−0.020	−0.026
	[0.020]	[0.020]	[0.020]	[0.020]	[0.020]
Water piped or from tube well	−0.019	−0.016	−0.017	−0.021	−0.018
	[0.021]	[0.021]	[0.020]	[0.020]	[0.020]
Sealed toilet or latrine	−0.030	−0.011	−0.015	−0.018	−0.015
	[0.025]	[0.023]	[0.023]	[0.023]	[0.023]
Child has one or more siblings under 6 years old	0.031	0.035*	0.031	0.031	0.032
	[0.022]	[0.021]	[0.021]	[0.021]	[0.021]
No. members under 15	0.018*	0.020**	0.022**	0.022**	0.022**
	[0.011]	[0.010]	[0.010]	[0.010]	[0.010]
No. working age members	−0.006	−0.004	−0.004	−0.005	−0.004
	[0.008]	[0.008]	[0.008]	[0.008]	[0.008]
No. members over 65	−0.025	−0.022	−0.023	−0.026	−0.024
	[0.023]	[0.022]	[0.022]	[0.022]	[0.022]
Household head is male	0.025	0.009	0.021	0.015	0.021
	[0.029]	[0.027]	[0.027]	[0.027]	[0.027]
Household head is literate	−0.003	−0.010	−0.011	−0.011	−0.011
	[0.020]	[0.020]	[0.019]	[0.020]	[0.019]
Household head education, higher secondary or above	−0.125**	−0.141***	−0.141***	−0.139***	−0.144***
	[0.052]	[0.051]	[0.050]	[0.050]	[0.050]
Dietary Diversity Score (10 food groups)	−0.016**	−0.014**	−0.015**	−0.013**	−0.014**
	[0.007]	[0.006]	[0.006]	[0.006]	[0.006]
Domestic abuse	0.022	0.031*	0.029	0.029	0.029
	[0.019]	[0.018]	[0.018]	[0.018]	[0.018]
Observations	3343	3538	3596	3578	3603

The tables report marginal effects. Robust standard errors in brackets, clustered at the village level. ***p < 0.01, **p < 0.05, *p < 0.1.

Interestingly, input in productive decisions, without taking the autonomy of these decisions into account, was not associated with improvements in *haz* scores. This may be because autonomy, which in this survey describes the ability to make decisions based on personal values rather than outside pressures, is likely a stronger indicator of actual empowerment than simply some degree of input in decision-making. Input, but not autonomy, in productive decisions may indicate that a woman's decision-making power is limited to situations where her own productive decisions align with the preferences of her husband, in-laws or others in the community. If this is the case, she may not be able to change the allocation of productive resources away from the unitary or "dictator" model of the household. This highlights the importance of autonomy in discussions of women's empowerment, particularly when making inferences about how and whether empowerment indicators translate to greater bargaining power in the home.

The children of women who feel comfortable speaking up in public about things that are important to themselves, their families or the community have significantly greater *haz* scores, suggesting that women who are empowered to advocate for their own needs and/or the needs of their children have a significant positive impact on their children's nutritional status. Speaking in public may signal a high level of social capital in the community, a resource that women may be able to draw from to assist in child care and protect against times of hardship. It also suggests a higher

degree of self-esteem, which may in turn reflect a higher status within the household and enable women to provide a higher quality of care. Group membership was also positively related to nutrition but did not reach significance. A possible explanation is that group membership is a weaker indicator of self-esteem and social capital compared to speaking in public, since membership does not necessarily involve a leadership role or the willingness to contradict the decisions of others in the group.

Additionally, the presence of siblings under 6 years old is significantly negatively correlated with children's own *haz* scores, likely due to greater competition for the household's available resources. This relationship is observed for stunting, but not for short-term nutritional outcomes, wasting and underweight.

4.3. Panel random-effects

The panel analysis results are presented in Table 6 in terms of a random-effects model. District dummies and child gender are omitted from these models as there is no within variation, whilst small variation within the household head's secondary education over time suggests its coefficient may not be well identified. An *F*-test of the null hypothesis that constant terms are equal across units is rejected, indicating that pooled OLS may not produce consistent estimates.

In this random-effects model, women's overall 5DE score, autonomy in production and confidence speaking in public are no longer significantly associated with *haz* scores, while the coefficients on control over use of income and group membership are negative and not statistically significant. The positive association between haz scores and autonomy in production, and the lack of significance with control over asset indicators of empowerment is consistent with Cunningham, Ploubidis et al.'s (2015) study from Nepal which also used the WEAI index.

These panel results likely arise from the fact the longitudinal data is limited to two time periods only four years apart. It is unlikely that women in the sample have made significant gains in empowerment in this time, given that this is typically a much more gradual societal process. Nonetheless, summary statistics showed quite large changes in the proportion of women who were empowered in the 10 domains of the WEAI between the two years; with significant increases in overall 5DE, input in productive decisions, control over use of income and speaking in public; and significant decreases in autonomy in production and group membership. From this analysis we are unable to distinguish real gains (or losses) in empowerment from the possibility of some form of response bias, for example time to reflect on and discuss the survey questions with others producing different responses or interpretations of the questions in the second round.

Given this indication of some type of response bias, this form of measurement error in the empowerment variables is likely limiting the ability of the panel analysis to correctly estimate individual-level effects. This measurement error, in addition to the short panel, restricts the ability of this study to use the existing panel to draw inferences about how children's nutritional outcomes respond to changes in women's empowerment over time; that is, inferences that are more causal in nature.

4.4. Probit estimation results

Table 6 displays the Probit estimates of the probability of a child being stunted. These marginal effects represent the partial effect of each explanatory variable on the dependent variable, stunting, keeping the other explanatory variables fixed at their means. Rows (1) to (5) display the marginal effects of a change from 0 to 1 in the empowerment indicator variables. The marginal effect of speaking in public is, on average, a 4.6 percentage point decrease in the probability that a child is stunted, and is statistically significant at the 1 per cent level. The marginal effect of women's autonomy in production is of a similar magnitude; on average a 4.1 percentage point decrease in the probability of stunting, significant this time at the 10 per cent level.

The direction and significance of these results are broadly consistent with the results of the pooled OLS, highlighting the relevance of autonomy in production and confidence speaking in public, in particular to improved child stunting outcomes. This result may thus be of more policy interest than the OLS relationship between empowerment and *haz* scores, which is influenced for example by whether empowerment is associated with improved *haz* scores for children who already have *haz* scores around the mean of a healthy reference group.

4.5. Influence of women's empowerment on household dietary diversity

This analysis has tested the relationship between women's empowerment and children's food security outcomes, controlling for the household's access to a variety of foods. Consistent with previous literature (Arimond & Ruel, 2004), the household's dietary diversity was found to be associated with better stunting outcomes after controlling for other socioeconomic characteristics. In general, household-level food security is expected to be correlated with children's food security. This section therefore investigates the relationship between the WEAI variables and households' dietary diversity, to test if women's empowerment in agriculture is associated with better nutrition outcomes when the household is the unit of observation. If greater empowerment is associated with higher dietary diversity at the household-level, this presents an additional mechanism through which empowered women may influence the nutritional outcomes of children in the household.

Table 8 presents the results from the household-level model. In keeping with Sraboni and Quinsumbing (2018) and Sraboni et al.'s (2014) research using the first wave of the BIHS dataset, our study also finds that the five WEAI indicator variables, as well as women's overall empowerment (5DE) score, are significantly correlated with households' dietary diversity scores. The associated increases are small, around 0.1 to 0.2 food groups for each individual indicator, however the larger coefficient on women's overall empowerment score, constructed from these indicators, suggests that the positive relationships are to some degree additive. Households where women are empowered in all 10 dimensions of the WEAI consumed, on average, 0.62 more food groups out of 10 in the week leading up to the survey.

Given that households' dietary diversity is associated with improvements in children's *haz* scores in the main estimations, the significant positive correlation between the empowerment variables and household-level dietary diversity provides another mechanism through which empowerment is related to improvements in child nutrition.

4.6. Robustness tests

Finally, in Appendix A we present results from our robustness tests. Each empowerment indicator was initially included in the regression separately, as including all five in a single regression can easily reduce the significance of individual empowerment indicators due to collinearity between them. For example, input in productive decisions is in theory a necessary, but not sufficient, condition for autonomy in production. Similarly, group membership provides a forum for speaking in public.

However, the final estimation results are robust to a specification that includes all five indicators in a single model, as shown in Appendix A: Table A5. Our analysis consistently finds the two

Table 8
Effect of women's empowerment on household's dietary diversity: OLS estimates.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Empowerment variables						
5DE score	0.624***					
	[0.088]					
Input in productive decisions		0.122***				
		[0.042]				
Autonomy in production			0.182***			
			[0.043]			
Control over use of income				0.107**		
				[0.042]		
Speaking in public					0.198***	
					[0.035]	
Group membership						0.118***
						[0.039]
Household characteristics						
Division dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year 2 (2015)	0.686***	0.705***	0.729***	0.712***	0.671***	0.723***
	[0.040]	[0.042]	[0.040]	[0.040]	[0.042]	[0.040]
Ln(total land + 1)	0.087***	0.090***	0.099***	0.094***	0.096***	0.100***
	[0.010]	[0.010]	[0.010]	[0.010]	[0.010]	[0.010]
Household has electricity	0.411***	0.433***	0.412***	0.425***	0.413***	0.418***
	[0.039]	[0.040]	[0.039]	[0.039]	[0.039]	[0.039]
Water piped or from tube well	0.127***	0.123***	0.127***	0.126***	0.120***	0.123***
	[0.038]	[0.039]	[0.038]	[0.038]	[0.039]	[0.038]
Sealed toilet or latrine	0.276***	0.285***	0.286***	0.281***	0.289***	0.275***
	[0.050]	[0.051]	[0.051]	[0.050]	[0.051]	[0.050]
No. members under 15	0.020	0.018	0.021	0.019	0.018	0.018
	[0.017]	[0.018]	[0.017]	[0.017]	[0.017]	[0.017]
No. working age members	0.122***	0.113***	0.124***	0.124***	0.124***	0.122***
	[0.015]	[0.015]	[0.015]	[0.015]	[0.015]	[0.015]
No. members over 65	0.089**	0.080**	0.065*	0.077**	0.075**	0.073**
	[0.035]	[0.036]	[0.036]	[0.035]	[0.036]	[0.035]
Household head is male	0.003	0.013	−0.004	−0.006	0.009	−0.008
	[0.046]	[0.048]	[0.046]	[0.046]	[0.046]	[0.046]
Household head is literate	0.402***	0.390***	0.397***	0.405***	0.400***	0.404***
	[0.033]	[0.034]	[0.033]	[0.032]	[0.032]	[0.033]
Household head education, higher secondary or above	0.386***	0.388***	0.376***	0.376***	0.345***	0.383***
	[0.076]	[0.080]	[0.077]	[0.076]	[0.075]	[0.076]
Domestic abuse	−0.073*	−0.074*	−0.068*	−0.072*	−0.083**	−0.079**
	[0.037]	[0.039]	[0.037]	[0.038]	[0.037]	[0.038]
Constant	5.413***	5.777***	5.658***	5.726***	5.731***	5.760***
	[0.113]	[0.108]	[0.104]	[0.102]	[0.096]	[0.100]
Observations	10,181	9456	10,023	10,162	10,088	10,181

Robust standard errors in brackets, clustered at the village level.
***p < 0.01, **p < 0.05, *p < 0.1.

empowerment variables – autonomy in production and confidence speaking in public to be statistically significant. The estimated coefficients and significance of all included variables are effectively unchanged as indicators are added into or taken out of the regression, with the exception of the dummy for the year = 2015, which gradually loses significance as additional indicators are added. This is potentially because as the number of empowerment variables in the model increases, more of the variation over time is captured by changes in these variables between 2011 and 2015, and less by the year dummy.

4.7. Does the relationship between empowerment and nutrition differ for girls and boys?

There are varied examples in the literature to suggest that women (and men) allocate resources differently between sons and daughters; Thomas (1994) provides a well-known example, finding that mothers' education has a larger effect on the height of daughters, and fathers' education on the height of sons, using household data from Brazil, Ghana and the United States. On the other hand, son preference or other economic considerations may lead more of the benefits from improvements in women's bargaining power to accrue to sons rather than daughters, a relationship Haddad and Hoddinott (1994) observe in Côte d'Ivoire.

To test whether women's empowerment affects the nutritional status of male and female children differently, we re-estimate the previous models adding an interaction term between the empowerment variables and a dummy variable for the child's sex (=1 if the child is female).

Notably, in Appendix Table A4, only one of the interaction term coefficients is statistically significant for any of the models, either in the pooled OLS or panel random-effects. The interaction term is statistically significant only for group membership *female at the 10% level, and shows that female empowerment measured using group membership is statistically significant at improving the *haz* scores of girls.[5] These results indicate that women's empowerment affects the nutrition of both girls and boys under five equally across all dimensions in this analysis, with the possible exception of group membership.

[5] The coefficient for the interaction term (**group membership *female**) is **−0.174***. The interpretation of this coefficient is as follows: $\text{empowerment}\hat{b}_1$ + $\text{female}\hat{b}_2$ + $\text{female} * \text{empowerment}\hat{b}_3$ = 0.109 + 0.157 − **0.174** = 0.092

5. Conclusions

This paper sought to analyse whether measures of women's empowerment (measured using indicators from five domains of empowerment of the innovative, multi-dimensional WEAI) are associated with improvements in child nutrition in Bangladesh. This analysis has clarified which aspects of female empowerment translate to better nutritional outcomes in this context, particularly in relation to the persistent problem of child stunting observed in Bangladesh. Our key findings are that: (i) women's overall autonomy measured using the five domains of empowerment (5DE) is significantly associated with better height-for-age z-scores (*haz)* for children aged between 6 and 59 months, and better household dietary diversity in the pooled OLS model; and *(ii)* The specific empowerment measures have mixed results, with autonomy in making productive decisions and confidence to speak up in public being significantly associated with improvements in children's *haz,* and a lower probability of stunting. In particular, Sraboni et al. (2014) find that in Bangladesh, the empowerment gap is greatest in the leadership domain, so our finding of a positive influence on child *haz* scores from having a mother with confidence speaking in public is important.

To the best of our knowledge, our analysis is the first published research linking WEAI to child nutrition in Bangladesh. These findings are valuable in increasing our understanding of how different dimensions of women's empowerment can play a role in reducing the rates of child stunting in Bangladesh, with a particular focus on women's empowerment in agriculture. It is theorised that progress in female empowerment indicators over time will lead to further improvements in child stunting, however this study limited in its ability to draw conclusions due to the short duration of the panel. Continued efforts to measure empowerment over a longer time period, using multi-dimensional tools such as the WEAI, are needed to advance this area of research and should be implemented alongside policy interventions to expand women's empowerment as part of a larger development goal.

However, there is additional information to be gained from researching the precise mechanisms driving the association between improved *haz* scores and women's autonomy in productive decisions and confidence speaking in public. The literature suggests that (a) gender differences in preferences for intrahousehold allocation of resources and (b) a positive effect of higher social capital and self-esteem may be driving these results.

An important qualification to any result in this area is that child anthropometrics cannot precisely capture the relationship between greater nutritional inputs on behalf of more empowered mothers, where these exist, and nutritional outcomes. This is due to a large collection of unobserved variables affecting child growth measurements; including in utero growth and development, nutritional deficiencies, and short- and long-term disease and illness (Black et al., 2013). These risk factors are in many cases undiagnosed and heterogeneous in their duration and effects on nutrition.

These findings are valuable in increasing our understanding of how different dimensions of women's empowerment can play a role in reducing the rates of child stunting in Bangladesh, with a particular focus on women's empowerment in agriculture. It is theorised that progress in these empowerment indicators over time will lead to further improvements in child stunting, however this study is limited in its ability to draw conclusions due to the short duration of the panel.

However, the data is limited to observations in two time periods less than four years apart. As this is an observational study, it is unlikely that the surveyed women will have made significant achievements in expanding their empowerment in that time.

Another consideration is the potential for some degree of response bias in self-reported surveys, as suggested by a greater-than-expected change in many of the empowerment indicators between the first and second round of the survey. For example, the number of women in the sample who report input in productive decisions rises from 61 per cent in 2011 to 91 per cent in 2015. Only three of the ten indicators showed no significant change in the proportion of women empowered. Without additional information, it is not possible to determine how much of the change in responses at the second round is due to some form of response bias. Qualitative surveys are needed to determine why women may change their responses in the follow-up round, besides real progress in the empowerment, particularly if the aim is to conduct longitudinal analysis in the future using the WEAI or similar survey instruments.

Overall there is strength to the positive correlation between female empowerment and child stunting outcomes, particularly in relation to women's autonomy in productive decisions and speaking in public. This is consistent with a range of empirical evidence to support the hypothesis that when more of the household's resources and decision-making power are in the hands of women, more of the household's resources are diverted towards the needs of young children, contrary to the unitary approach to the household.

Interestingly, input in productive decisions, without taking the autonomy of these decisions into account, was not associated with improvements in *haz* scores. This may be because autonomy, which in this study describes the ability to make decisions based on personal values rather than outside pressures, is likely a stronger indicator of actual empowerment than simply some degree of input in decision-making. Input, but not autonomy, in productive decisions may indicate that a woman's decision-making power is limited to situations where her own productive decisions align with the preferences of her husband, in-laws or others in the community.

Continued efforts to measure empowerment over a longer time period, using multi-dimensional tools such as the WEAI, are needed to advance this area of research and should be implemented alongside policy interventions to expand women's empowerment as part of a larger development goal.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

Table A1
Summary statistics by household head – full sample.

Variables	Hh head is female mean	Hh head is male mean	Difference	*t*-test
Child's age (months)	32.77	31.77	1.00	−1.56
Child's age squared (months)	1298.72	1243.78	54.95	−1.32
Child's gender = male	0.52	0.51	0.01	−0.35
Child has one or more siblings under 6 years old	0.33	0.37	−0.04*	(-2.08)
Length/height-for-age Z-score	−1.73	−1.79	0.06	−1.12
Weight-for-age Z-score	−1.44	−1.61	0.18***	−3.97
Weight-for-length/height Z-score	−0.67	−0.88	0.21***	−4.32
Stunting, low (haz <=-1)	0.76	0.77	−0.01	(−0.58)
Stunting, moderate (haz <=-2)	0.46	0.45	0.01	−0.45
Stunting, severe (haz <=-3)	0.15	0.16	−0.01	(−0.59)
Underweight, low (waz <=-1)	0.69	0.74	−0.05**	(−2.61)
Underweight, moderate (waz <=-2)	0.29	0.35	−0.06**	(−3.04)
Underweight, severe (waz <=-3)	0.07	0.08	−0.02	(−1.41)
Wasting, low (whz <=-1)	0.37	0.45	−0.08***	(−3.75)
Wasting, moderate (whz <=-2)	0.11	0.15	−0.04**	(−2.84)
Wasting, severe (whz <=-3)	0.03	0.04	−0.01	(−1.59)
WEAI variables				
5DE score, women	0.67	0.65	0.01	−1.37
Input in productive decisions, women	0.75	0.76	−0.01	(−0.35)
Control over use of income, women	0.77	0.81	−0.04*	(−2.14)
Autonomy in production, women	0.81	0.82	−0.01	(−0.43)
Ownership of asset, women	0.94	0.79	0.15***	−11.55
Purchase, sale or transfer of asset, women	0.57	0.56	0.01	−0.25
Access to and decision on credit, women	0.52	0.52	−0.01	(−0.30)
Speaking in Public, women	0.52	0.44	0.07**	−3.15
Group member, women	0.25	0.26	−0.01	(−0.71)
Leisure, women	0.75	0.71	0.04	−1.86
Workload, women	0.82	0.74	0.08***	−4.44
Gender parity gap (difference between men's and women's Five DE)	−0.16	0.08	−0.24*	(−3.89)
Household characteristics				
Child has one or more siblings under 6 years old	0.33	0.37	−0.04*	(−2.08)
No. members under 15	2.35	2.30	0.05	−1.03
No. working age members	1.53	2.74	−1.20***	(−29.78)
No. members over 65	0.14	0.21	−0.07***	(−4.25)
Household head is literate	0.66	0.50	0.16***	−7.77
Household head education, higher secondary or above	0.01	0.04	−0.02***	(−4.14)
Dietary Diversity Score (10 food groups)	7.83	7.79	0.04	−0.55
Land, total (ha)	41.50	90.67	−49.16***	(−11.03)
Ln (total land + 1)	2.25	3.17	−0.92***	(−11.51)
Household has electricity	0.58	0.51	0.07***	−3.35
Water piped or from tubewell	0.59	0.66	−0.07**	(−3.20)
Sealed toilet or latrine	0.86	0.80	0.06***	−3.78
Based on threaten divorce, threaten remarry, verbal abuse, and physical	0.20	0.41	−0.21***	(−11.75)
Primary Male-Female age difference	7.18	7.69	−0.51	(−0.18)
Observations (full sample: 4099)	664	3435		

Notes: We include children aged 6–59 months.

Table A2
Effect of women's empowerment indicators on children's haz scores, 6–59 months: pooled OLS estimates.

	Dependent variable: Children's *haz* scores				
	(1)	(2)	(3)	(4)	(5)
VARIABLES					
Empowerment variables					
Ownership of assets	0.046				
	[0.058]				
Purchase, sale or transfer of assets		−0.011 [0.044]			
Access to and decisions over credit			−0.063 [0.043]		
Leisure				0.028	
				[0.049]	
Workload					0.078*
					[0.044]
Child variables					
Child's age (months)	−0.059***	−0.059***	−0.059***	−0.058***	−0.059***
	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]
Child's age squared (months)	0.001***	0.001***	0.001***	0.001***	0.001***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Child's gender = male	−0.111**	−0.111**	−0.110**	−0.110**	−0.114**
	[0.044]	[0.044]	[0.044]	[0.044]	[0.044]
Household characteristics					
Year 2 (2015)	0.142***	0.143***	0.147***	0.146***	0.143***
	[0.042]	[0.043]	[0.042]	[0.042]	[0.042]
Division dummies	Yes	Yes	Yes	Yes	Yes
Ln(total land + 1)	0.048***	0.050***	0.049***	0.049***	0.049***
	[0.014]	[0.015]	[0.014]	[0.014]	[0.014]
Household has electricity	0.074	0.076	0.077	0.073	0.075
	[0.049]	[0.049]	[0.049]	[0.051]	[0.049]
Water piped or from tube well	0.089*	0.087*	0.085	0.087*	0.086*
	[0.052]	[0.051]	[0.051]	[0.052]	[0.051]
Sealed toilet or latrine	−0.003	0.002	−0.002	−0.002	0.003
	[0.059]	[0.058]	[0.057]	[0.058]	[0.058]
Child has one or more siblings under 6 years old	−0.120**	−0.122**	−0.122**	−0.119**	−0.114**
	[0.053]	[0.053]	[0.053]	[0.053]	[0.053]
No. members under 15	−0.038	−0.038	−0.036	−0.039	−0.037
	[0.025]	[0.025]	[0.025]	[0.025]	[0.025]
No. working age members	0.010	0.009	0.006	0.009	0.009
	[0.022]	[0.022]	[0.022]	[0.022]	[0.022]
No. members over 65	0.037	0.034	0.032	0.034	0.034
	[0.051]	[0.051]	[0.051]	[0.051]	[0.051]
Household head is male	−0.095	−0.100	−0.096	−0.100	−0.096
	[0.067]	[0.066]	[0.067]	[0.067]	[0.067]
Household head is literate	0.101*	0.101*	0.100*	0.099*	0.103**
	[0.052]	[0.052]	[0.052]	[0.052]	[0.052]
Household head education, higher secondary or above	0.495***	0.495***	0.487***	0.495***	0.501***
	[0.141]	[0.141]	[0.140]	[0.141]	[0.141]
Dietary Diversity Score (10 food groups)	0.032*	0.033**	0.033**	0.032**	0.033**
	[0.016]	[0.016]	[0.016]	[0.016]	[0.016]
Domestic abuse	−0.087**	−0.087**	−0.085**	−0.084**	−0.083**
	[0.041]	[0.041]	[0.041]	[0.041]	[0.041]
Constant	−1.292***	−1.258***	−1.226***	−1.284***	−1.328***
	[0.187]	[0.188]	[0.191]	[0.193]	[0.195]
Observations	3603	3603	3601	3598	3598

Robust standard errors in brackets, clustered at the village level.
***p < 0.01, **p < 0.05, *p < 0.1.

Table A3
Marginal effects on child stunting (haz ≤ – 2), full sample of children 6–59 months.

	Dependent variable: Child is stunted (*haz ≤ – 2*)				
	(1)	(2)	(3)	(4)	(5)
VARIABLES					
Empowerment variables					
Ownership of assets	0.010 [0.022]				
Purchase, sale or transfer of assets		0.024 [0.019]			
Access to and decisions over credit			0.024 [0.018]		
Leisure				−0.031 [0.020]	
Workload					−0.013 [0.021]
Child variables					
Child's age (months)	0.022***	0.022***	0.022***	0.022***	0.022***
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Child's age squared (months)	−0.000***	−0.000***	−0.000***	−0.000***	−0.000***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Child's gender = male	0.047***	0.048***	0.047***	0.047**	0.048***
	[0.018]	[0.018]	[0.018]	[0.018]	[0.018]
Household characteristics					
Division dummies	Yes	Yes	Yes	Yes	Yes
Year 2 (2015)	−0.070***	−0.066***	−0.070***	−0.071***	−0.069***
	[0.018]	[0.019]	[0.018]	[0.018]	[0.018]
Ln(total land + 1)	−0.019***	−0.020***	−0.018***	−0.019***	−0.019***
	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]
Household has electricity	−0.026	−0.025	−0.026	−0.021	−0.026
	[0.020]	[0.020]	[0.020]	[0.021]	[0.020]
Water piped or from tube well	−0.017	−0.018	−0.017	−0.018	−0.016
	[0.020]	[0.020]	[0.020]	[0.020]	[0.020]
Sealed toilet or latrine	−0.017	−0.018	−0.015	−0.014	−0.016
	[0.023]	[0.023]	[0.023]	[0.023]	[0.023]
Child has one or more siblings under 6 years old	0.032	0.034	0.032	0.030	0.031
	[0.021]	[0.021]	[0.021]	[0.021]	[0.021]
No. members under 15	0.022**	0.021**	0.021**	0.022**	0.022**
	[0.010]	[0.010]	[0.010]	[0.010]	[0.010]
No. working age members	−0.004	−0.004	−0.004	−0.005	−0.004
	[0.008]	[0.008]	[0.008]	[0.008]	[0.008]
No. members over 65	−0.023	−0.023	−0.023	−0.023	−0.024
	[0.022]	[0.022]	[0.022]	[0.022]	[0.022]
Household head is male	0.021	0.022	0.019	0.021	0.020
	[0.027]	[0.027]	[0.027]	[0.027]	[0.027]
Household head is literate	−0.011	−0.010	−0.011	−0.009	−0.012
	[0.019]	[0.019]	[0.019]	[0.019]	[0.019]
Household head education, higher secondary or above	−0.143***	−0.144***	−0.140***	−0.144***	−0.145***
	[0.050]	[0.050]	[0.050]	[0.050]	[0.050]
Dietary Diversity Score (10 food groups)	−0.014**	−0.014**	−0.014**	−0.014**	−0.014**
	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]
Domestic abuse	0.028	0.028	0.028	0.027	0.028
	[0.018]	[0.018]	[0.018]	[0.018]	[0.018]
Observations	3603	3603	3601	3598	3598

Robust standard errors in brackets, clustered at the village level.
***p < 0.01, **p < 0.05, *p < 0.1.

Table A4
Interaction terms between empowerment indicators and child gender $\boldsymbol{c} = b_0 + b_1 empowerment + b_2(femalechild) + b_3(empowerment * female) + b_5\boldsymbol{I} + b_6\boldsymbol{H} + b_7\boldsymbol{C} + \varepsilon(2)$.

	Pooled OLS	Panel random-effects
1.		
Input in productive decisions	0.121	0.019
	[0.077]	[0.158]
Input in productive decisions × child gender	−0.072	0.033
	[0.105]	[0.192]
2.		
Autonomy in production	0.179**	0.277**
	[0.077]	[0.140]
Autonomy in production × child gender	0.026	−0.248
	[0.105]	[0.191]
3.		
Control over use of income	0.011	−0.127
	[0.099]	[0.154]
Control over use of income × child gender	−0.028	0.002
	[0.080]	[0.201]
4.		
Speaking in public	0.132**	0.071
	[0.062]	[0.111]
Speaking in public × child gender	0.081	−0.028
	[0.085]	[0.145]
5.		
Group membership	0.109	−0.063
Gender = 1 if child is female	[0.071] 0.157***	[0.123]
Group membership × child gender	[0.050] **−0.174***	−0.025
	[0.100]	[0.172]

Robust standard errors in brackets, clustered at the village level. ***p < 0.01, **p < 0.05, *p < 0.1.
The first row under each number shows the empowerment coefficient estimate, $\hat{b}_1$, when interaction terms are included. The second row displays the female gender coefficient, $\hat{b}_2$ and $\hat{b}_3$ represents the interaction term coefficient estimate. Significant interaction terms shown in bold. Models are estimated separately for each empowerment indicator, as in the main estimations. Control variables are the same as the main estimations.

Table A5
Robustness to alternative specifications (shown for pooled OLS estimation).

	Dependent variable: Children's *haz* scores				
VARIABLES	(1)	(2)	(3)	(4)	(5)
Empowerment variables					
Input in productive decisions	0.085	0.094*	0.099	0.085	0.084
	[0.054]	[0.055]	[0.061]	[0.061]	[0.061]
Autonomy in production		0.191***	0.193***	0.186***	0.185***
		[0.057]	[0.057]	[0.056]	[0.056]
Control over use of income			−0.005	−0.004	−0.004
			[0.071]	[0.071]	[0.071]
Speaking in public				0.194***	0.193***
				[0.045]	[0.046]
Group membership					0.011
					[0.049]
Household characteristics					
Child's age (months)	−0.055***	−0.055***	−0.055***	−0.055***	−0.055***
	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]
Child's age squared (months)	0.001***	0.001***	0.001***	0.001***	0.001***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Child's gender = male	−0.110**	−0.107**	−0.108**	−0.109**	−0.109**
	[0.045]	[0.045]	[0.045]	[0.046]	[0.046]
Division dummies	Yes	Yes	Yes	Yes	Yes
Year 2 (2015)	0.108**	0.122**	0.121**	0.077	0.078
	[0.047]	[0.048]	[0.048]	[0.049]	[0.049]
Ln(total land + 1)	0.049***	0.047***	0.047***	0.045***	0.045***
	[0.015]	[0.015]	[0.015]	[0.015]	[0.015]
Household has electricity	0.051	0.056	0.055	0.040	0.039
	[0.051]	[0.051]	[0.052]	[0.053]	[0.052]
Water piped or from tube well	0.088	0.086	0.088	0.091	0.091
	[0.054]	[0.056]	[0.056]	[0.057]	[0.057]
Sealed toilet or latrine	0.036	0.032	0.032	0.048	0.047
	[0.061]	[0.062]	[0.062]	[0.062]	[0.062]
Child has one or more siblings under 6 years old	−0.106*	−0.116**	−0.115**	−0.111**	−0.110**
	[0.056]	[0.056]	[0.056]	[0.056]	[0.056]
No. members under 15	−0.037	−0.031	−0.031	−0.034	−0.034
	[0.026]	[0.026]	[0.026]	[0.026]	[0.026]
No. working age members	0.011	0.011	0.011	0.013	0.013
	[0.022]	[0.022]	[0.022]	[0.022]	[0.022]

(*continued on next page*)

Table A5 (*continued*)

	Dependent variable: Children's *haz* scores				
VARIABLES	(1)	(2)	(3)	(4)	(5)
No. members over 65	0.026	0.028	0.028	0.028	0.028
	[0.053]	[0.054]	[0.054]	[0.053]	[0.053]
Household head is male	−0.109	−0.082	−0.083	−0.060	−0.060
	[0.069]	[0.071]	[0.071]	[0.070]	[0.070]
Household head is literate	0.086	0.091*	0.092*	0.090*	0.090*
	[0.053]	[0.053]	[0.053]	[0.054]	[0.054]
Household head education, higher secondary or above	0.494***	0.477***	0.477***	0.465***	0.466***
	[0.148]	[0.149]	[0.149]	[0.149]	[0.149]
Dietary Diversity Score (10 food groups)	0.034**	0.034**	0.034**	0.033*	0.032*
	[0.017]	[0.017]	[0.017]	[0.017]	[0.017]
Domestic abuse	−0.084*	−0.086**	−0.086**	−0.100**	−0.100**
	[0.043]	[0.043]	[0.043]	[0.043]	[0.043]
Constant	−1.422***	−1.552***	−1.558***	−1.635***	−1.637***
	[0.204]	[0.215]	[0.216]	[0.216]	[0.216]
Observations	3343	3278	3277	3258	3258
R-squared	0.067	0.071	0.071	0.077	0.077

Robust standard errors in brackets, clustered at the village level.
***p < 0.01, **p < 0.05, *p < 0.1.

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