Title Page

Title: Water, sanitation and hygiene practices mediate the association between women's empowerment and child length-for-age z-scores in Nepal

Short running title: Women's empowerment and child nutritional status in Nepal

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Abstract and Keywords

In Nepal, more than one-third of children are stunted. Prior studies have shown that women's empowerment in agriculture is associated with child (<2y) length-for-age z-scores (LAZ) in Nepal. This study tests whether child dietary diversity (DD) and household water, sanitation, and hygiene (WASH) facilities and practices mediate the associations between women's empowerment and LAZ. With a cross-sectional dataset of 4,080 households from 240 rural communities across 16 districts of Nepal, we used ordinary least squares regression models to first estimate the associations between women's empowerment and LAZ for children 6 to 24 months (n=1,402) (our previous published analysis included all children < 24 months of age). using the Women's Empowerment in Agriculture Index (WEAI)'s Five Domains of Empowerment (5DE) sub-index. We used standardized structural equation models to test whether child DD and/or household WASH mediated the association between women's empowerment and child LAZ. Overall, women's empowerment was positively associated with child LAZ (β:0.24, P:0.03), as found in our previous analyses. In the mediation analysis, women's empowerment was positively associated with WASH (β:0.78, P:<0.001), and in turn child LAZ (β:0.09, P:<0.001). Women's empowerment was not associated with DD, but DD was associated with LAZ (β:0.06, P:0.05). Empowered women had better WASH practices, than non-empowered women, which translated into higher child LAZ. Child DD was not a mediating factor in the association between women's empowerment and child LAZ. More research is needed to explore other pathways by which women's empowerment may affect child nutrition outcomes.

Keywords/Phrases: Women's empowerment; child nutrition; mediation; Nepal; WASH; dietary diversity

Main text

Abstract

In Nepal, more than one-third of children are stunted. Prior studies have shown that women's empowerment in agriculture is associated with child (<2y) length-for-age z-scores (LAZ) in Nepal. This study tests whether child dietary diversity (DD) and household water, sanitation, and hygiene (WASH) facilities and practices mediate the associations between women's empowerment and LAZ. With a cross-sectional dataset of 4,080 households from 240 rural communities across 16 districts of Nepal, we used ordinary least squares regression models to first estimate the associations between women's empowerment and LAZ for children 6 to 24 months (n=1,402) (our previous published analysis included all children < 24 months of age). using the Women's Empowerment in Agriculture Index (WEAI)'s Five Domains of Empowerment (5DE) sub-index. We used standardized structural equation models to test whether child DD and/or household WASH mediated the association between women's empowerment and child LAZ. Overall, women's empowerment was positively associated with child LAZ (β:0.24, P:0.03), as found in our previous analyses. In the mediation analysis, women's empowerment was positively associated with WASH (β:0.78, P:<0.001), and in turn child LAZ (β:0.09, P:<0.001). Women's empowerment was not associated with DD, but DD was associated with LAZ (β:0.06, P:0.05). Empowered women had better WASH practices, than non-empowered women, which translated into higher child LAZ. Child DD was not a mediating factor in the association between women's empowerment and child LAZ. More research is needed to explore other pathways by which women's empowerment may affect child nutrition outcomes.

Introduction

Stunting, which is a reflection of the cumulative effects of poor nutrition, infections and other determinants over time, contributes to poor child health and development.(Bhutta, 2013; Black et al., 2013; Hoddinott et al., 2013) In Nepal, 41% of children under 5 years of age are stunted and 16% of these children are severely stunted. This stark nutritional situation is undoubtedly caused by a variety of factors including poor diets and childcare practices, insufficient access to health services, lack of clean water, and limited access to sanitation and hygiene facilities.(Joshi, Agho,

Dibley, Senarath, & Tiwari, 2012; Ministry of Health and Popualation (MOHP), 2006; Ministry of Health and Popualation (MOHP) Nepal, 2012)

The conceptual framework developed by Engle and colleagues highlights women's autonomy and empowerment as key caregiving resources.(Engle, Menon, & Haddad, 1999) Control of household resources, autonomy, and social support are understood to be important resources that can contribute to child nutrition if mothers use these resources to adopt optimal caregiving and hygiene practices. (UNICEF, 1990)·(Engle et al., 1999) Previous studies have documented positive associations between women's autonomy, control over resources and other aspects of empowerment and child development outcomes, (Quisumbing, 2003; Yoong, Rabinovich, & Diepeveen, 2012) but limited research exists on the pathways that operate between maternal caregiving resources and child nutrition outcomes.

In South Asia, studies show that the low social status of women and their limited access – and control over - resources contribute substantially to poor child nutritional status.(Cunningham, Ruel, Ferguson, & Uauy, 2014; Smith, Ramakrishnan, Ndiaye, & Haddad, 2003) Specifically, several previous empirical studies in South Asia have found associations between women's empowerment and child height/length-for-age (HAZ/LAZ), weight-for-age (WAZ), or weight-for-height/length (WHZ/WLZ) z-scores.[45,](Desai & Johnson, 2005)[,52,59] Evidence relating the WEAI itself to food security and health and nutrition outcomes is also emerging.(Alkire et al., 2013; Sraboni, Malapit, Quisumbing, & Ahmed, 2014; United States Agency for International Development, International Food Policy Research Institute, Development, & Oxford Poverty and Human Development Initiative, 2012) However, these prior studies have not investigated how and why these factors are associated, i.e. what factors are part of the pathways between women's empowerment and child nutrition.(Cunningham et al., 2015; Malapit, Kadiyala, Quisumbing, Cunningham, & Tyagi, 2015; Sraboni et al., 2014)

Given Nepal's largely agrarian economy, many household decisions are centred around agriculture.(Ministry of Health and Popualation (MOHP) Nepal, 2012) Nearly all rural Nepalese women engage in subsistence agricultural production activities, including performing more than

70% of labour related to livestock production.(Miller, 2011; Paudel, ter Muelen, Wollny, Dahal, & Gauly, 2009) To capture decision-making and other dimensions of women's empowerment in this agrarian context, the Women's Empowerment in Agriculture Index (WEAI) was used in our previous analyses, which showed that several dimensions of empowerment –autonomy in household production decisions, satisfaction with time available for leisure activities, and access to and decision-making on credit – were associated with length for age z-scores (LAZ) among children 0-24 months.(Cunningham et al., 2015)

In this study, we expand our prior work to empirically test the pathways through which empowerment relates to child LAZ in children 6 to 24 months of age. We hypothesize that women's empowerment may influence child LAZ via improved dietary diversity (DD) and better household water, sanitation, and hygiene (WASH) facilities and practices. Not only are well-balanced diets and a clean environment known to contribute to child health and growth (Arimond & Ruel, 2004a; Cumming & Cairncross, 2016; Onyango, Borghi, de Onis, Casanovas, & Garza, 2013), but empowerment may enable mothers to make decisions regarding the foods they give to their children and the investments they make in WASH facilities, such as toilets and soap. Prior work on intra-household dynamics suggest that when women are in control of household resources, household health factors are positively influenced.(Lépine & Strobl, 2013; Richards & Kim, 2011; Thomas, 1990)

Key messages:

1. In the context of rural Nepal, women's empowerment was positively associated with LAZ among children 6 to 24 months of age (β:0.24, P:0.03)
2. In this same rural Nepal context, women's empowerment was seen to positively influence water, sanitation, and hygiene facilities and practices and in turn child linear growth, whereas child dietary diversity was not a mediating factor for this association.
3. More research is needed to explore other pathways for how women's empowerment may affect child nutritional status.

Methods

Data source and study sample

We used data from a cross-sectional baseline survey of an evaluation of *Suaahara,* a USAID-funded multi-sectoral intervention aiming to improve maternal and child health and nutrition. This survey was conducted in 16 districts throughout Nepal's three agro-ecological zones during the rainy season of 2012 (June-October).

Multi-stage cluster sampling was used to select 4,080 households across 240 wards, each household with at least one child less than five years of age. Eight districts were purposively selected because they were the initial *Suaahara* intervention districts and eight districts were then selected as the matched comparison districts based on their social, economic, and agro-ecological similarities with the intervention districts. Next, village development committees (n=5 per district) and rural wards (n=3 per village development committee) were randomly selected using probability proportional to size techniques. Finally, following a census of all households in each ward with at least one child (<5y), households (n=17 per ward) were randomly chosen. In households with more than one child (<5y), the index child was selected at random.(Cunningham & Kadiyala, 2013) For this study, we restricted our analysis to households with an index child between 6.0 and 23.9 months (6-24m) of age (n=1402), given that most growth faltering occurs during the first two years of life and that the complementary feeding pathway (dietary diversity) examined is intended for children 6 months of age or older.(Marie T Ruel, 2010; WHO Expert Committee on Physical Status, 1995)

Trained enumerators (n=70) fluent in the local languages conducted two household interviews, one of the mother of the index child and one to a household member responsible for major household decision-making, with preference given first to the mother of the index child's husband and second to another adult male. When no men were available, that interview was done with a female decision-maker. The survey questionnaires used in these interviews were field tested, revised, translated, and back translated. The questionnaire administered to mothers included questions

related to child health, care giving practices, infant and young child feeding practices including child DD, hygiene practices, household food security, maternal DD, maternal health, household access to information, and household access to water and sanitation facilities. The questionnaire administered to major household decision makers (mostly men) included questions regarding household composition, asset ownership, receipt of social assistance, and agricultural practices and use of land, as well as spot check observations to further assess household construction, availability of toilets, and sanitation and hygiene practices. Both household interviews included an identical set of questions regarding empowerment in household agricultural activities.

The ethics committees of the Nepal Health Research Council (NHRC), the International Food Policy Research Institute (IFPRI), and the London School of Hygiene and Tropical Medicine (LSHTM) approved this study. All respondents gave their informed consent to survey participation.

Measures and Variables

Outcome

All mothers and index children included in the survey had duplicate measurements of their weight and height/supine length taken using standardized calibrated digital weighing scales (Seca gmbh & Co. kg model 881 1021659; precision ±100 grams) and height/length boards (ShorrBoard produced by Weight and Measure LLC; precision ± 0.1 cm). Child date of birth was noted from a birth certificate (n=621; 44.3% of children 6-24m) or, when unavailable, by maternal recall. Child age was computed as number of days between date of birth and the date of the interview/measurement and then converted into age in months. Length-for age z-scores (LAZ) were computed using the World Health Organization (WHO) growth reference standards and recommendations: children with values outside the biologically plausible range (LAZ <-6/>6) were excluded from analysis.(Mei & Grummer-strawn, 2013; WHO, 2006) Logarithmic transformations were not necessary because z-scores were normally distributed. Stunting was defined as a z-score below -2 standard deviations (SD).(WHO, 2006; WHO Multicentre Growth Reference Study Group, 2006)

Primary Exposure – Women's Empowerment in Agriculture

The series of survey questions regarding empowerment in agriculture were those necessary for construction of the aggregate Women's Empowerment in Agriculture Index (WEAI). The WEAI is comprised of two sub-indexes: the five domains of empowerment (5DE) index (90% of the WEAI) and the gender parity index (GPI) (10% of the WEAI).(United States Agency for International Development et al., 2012) Due to Nepal's high levels of male emigration, dual-adult households were not available in 39% of the surveyed households with a child (6-24m). Therefore, we could not construct the gender parity index without losing a substantial portion of our sample and in turn, used the 5DE for this study. The 5DE uses the mothers' answers to the set of empowerment in agriculture questions, specifically related to the following 10 dimensions: 1) input into productive decisions; 2) autonomy in production; 3) asset ownership; 4) rights over assets; 5) access to and decision-making on credit; 6) control over the use of income; 7) membership in community groups; 8) comfort level speaking in public; 9) workload; and 10) satisfaction with leisure time. For aggregation, the 5DE uses a nested weighting structure: each of these 10 dimensions is weighted equally within its domain and each of the 5 domains is equally weighted. An individual is considered empowered in each of the ten dimensions if she meets a minimum threshold (Table 1).(Bhagowalia, Menon, Quisumbing, & Soundarajan, 2012; Sraboni, Malapit, Quisumbing, & Ahmed, 2012; United States Agency for International Development et al., 2012) We constructed binary variables for the aggregate 5DE index and each of its ten component indicators, with each variable representing empowerment in a specific dimension of women's empowerment in agriculture.[14]

Mediators –Dietary Diversity and Water, Sanitation, and Hygiene (WASH) Practices

This survey included a 24-hour qualitative dietary recall of foods consumed in the previous day. These foods were grouped into the following categories: grains, pulses, animal flesh, eggs, vitamin A rich fruits and vegetables, other fruits and vegetables, and dairy. A seven food group (7FG) dietary diversity index was constructed as a continuous variable to represent DD practices, as previous studies have shown the 7FG to be a reliable indicator of diet quality and a predictor of child growth status in lower-income countries.(Jones et al., 2013; Marriott, White, Hadden, Davies, & Wallingford, 2012; Organization, 2010; M. Ruel, Harris, & Cunningham, 2013)[,33]

To measure household water, sanitation, and hygiene (WASH) facilities and practices (or proxies for practices), we constructed ten yes/no binary variables from practices measured in the survey, either by household-level spot check observations (1-7 below) or by self-reporting (8-10 below):

(1) improved water source at the house including piped water into the dwelling, yard or plot, standpipe or public tap, a tubewell or borehold, protected well or bottled water;
(2) drinking water pot covered or do not store water at household level
(3) household has a toilet that is clean,
(4) house is free of both animal and human faeces;
(5) water and either soap or ash available at area identified for handwashing at the house;
(6) living area free of open garbage (other than only dry materials);
(7) living area where household members eat and/or cook free of animals;
(8) children (<5y) do not defecate in the open;
(9) proper disposal of child (<5y) stools including dropped into a toilet, rinsed into a drainage system, used for compost or buried; and
(10) maternal recall of five key times of day for washing hands including after defecation, after cleaning a child who defecated, before cooking/preparing food, before eating, and before feeding a child.

These household WASH characteristics were summed to create a continuous variable, a scale robust to the inclusion of both observation and recall data (alpha: 0.70).

Statistical Modelling

Statistical analyses were undertaken using Stata13.(StataCorp, 2013) Based on the conceptual framework by Engle and colleagues denoting the relationships between maternal caregiving resources (i.e. control of resources, autonomy, social support, and mental health), childcare practices, and child nutritional status,(Engle et al., 1999) we initially tested the relationships

between the WEAI 5DE and any of its ten component indicators of women's empowerment in agriculture and child LAZ, using adjusted ordinary least squares multivariate regression models. For the mediation analysis, we created an a priori conceptual framework to formally test our hypothesis that DD and/or household WASH facilities and practices may mediate the association of women's empowerment in agriculture and child LAZ in this setting (Figure 1), using standardized, adjusted linear structural equation models.

Based on a literature review of similar studies, our knowledge of the local context, and study design, we identified various child, maternal, and household factors that could be confounders of the associations of interest.(Aslam & Kingdon, 2012; Begum & Sen, 2009; Bose, 2011; Brennan, Mcdonald, & Shlomowitz, 2004; Dancer & Rammohan, 2009; De Silva & Harpham, 2007; Desai & Johnson, 2005; Mashal et al., 2008; Moestue, Huttly, Sarella, & Galab, 2007; Sethuraman, Lansdown, & Sullivan, 2006; M. Shroff et al., 2009; M. R. Shroff et al., 2011; Smith, Ramakrishnan, Ndiaye, Haddad, et al., 2003) In addition to district level clustering, we thus controlled for child sex, age, and age squared; maternal age, height, and education; and household wealth quintile, agro-ecological zone of residency (mountains, hills, and *terai*), and number of children under five years of age in our regression models. In the model testing dietary diversity as a mediator, we also controlled for breastfeeding status and whether the child had been ill during the two weeks preceding the survey.

Results

Participant characteristics

The mean age of the surveyed children included in this study was 15 months, and ranged from 6 to 23.9 months (Table 2). Mothers were 25 years of age on average and almost one-third of mothers had no formal education or less than one year of schooling. Households had fewer than six members on average and nearly two-thirds of the households had only one child less than 5 years of age.

Mean LAZ was -1.6 and approximately 38% of children were stunted. On average, children consumed foods from 3 of 7 food groups and their households engaged in about half of the ten optimal WASH practices measured and included in the scale. Among mothers, only about 9% were categorized as empowered in agriculture, according to the WEAI 5DE. Among the ten component indicators of the WEAI 5DE, the highest levels of empowerment were found in: asset ownership (85%), satisfaction with available leisure time (82%), confidence speaking in public (80%), and input into production decisions (81%). The lowest levels of empowerment related to indicators of: group membership (21%), access to and decision-making on credit (30%), autonomy in production decisions (30%), and workloads greater than 10.5 hours per day (35%).

Women's empowerment in agriculture, child LAZ, and two potential childcare mediators

Overall, women's empowerment in agriculture, as measured by the WEAI 5DE, was positively and significantly associated with child LAZ (β=0.24; P<0.05), as previously documented for the whole sample of children 0-24 m (β=0.20; P<0.05) (Cunningham et al., 2015) (Table 3). Also, consistent with prior findings, the following three dimensions of women's empowerment in agriculture had independent significant positive associations with child (6-24m) LAZ: satisfaction with the amount of time she has to engage in leisure activities (β=0.33; P<0.001); autonomy in household production decisions (β=0.19; P<0.05); and ability to access and make decisions about household credit (β=0.17; P<0.05).

Both hypothesized mediating variables – WASH facilities and practices and child DD – were independently and positively associated with child LAZ (Table 4). A one standard deviation (SD) increase in the WASH scale was associated with a 0.09 SD increase in child LAZ (P<0.001). Similarly, a one SD increase in child DD was associated with a 0.06 SD increase in child LAZ (P:0.05). Women's empowerment in agriculture overall, represented by the WEAI 5DE - was significantly associated with household WASH facilities and practices. The WEAI 5DE was not significant associated with child DD, also consistent with findings from our previous analysis.(Malapit et al., 2015) To formally assess mediation, we examined the indirect effects derived from a linear structural equation model. There was no significant indirect pathway from

women's empowerment in agriculture to child LAZ via child DD. However, the indirect pathway from women's empowerment in agriculture through household WASH facilities and practices and in turn, child LAZ was positive and significant: a one SD improvement in women's empowerment in agriculture was associated with a 0.78 SD improvement in household WASH facilities and practices (P<0.001) and a one SD improvement in household WASH facilities and practice was associated with a 0.09 SD improvement in child LAZ (P<0.001) (Figure 1).

Discussion

This study shows that in rural Nepal, women's empowerment in agriculture is associated with linear growth (LAZ) in children 6-24 months of age and that this association is partly mediated by improved WASH facilities and practices, but not by greater child DD. We also confirm our previous findings from an analysis of the whole sample of children < 24 months that showed that three of the 10 sub-domains of women's empowerment included in the overall indicator were positively and significantly associated with child LAZ: autonomy in production, access to and decisions about credit, and satisfaction with leisure time.(Cunningham et al., 2015)

WASH is a recognised determinant of child growth.(Dangour et al., 2013) In Nepal, water, sanitation, and hygiene facilities and practices are far from optimal. As of 2010, only half of all households had improved latrines and less than one in five Nepalese regularly consumed treated water. Open defecation persists in rural Nepal, increasing the risk of diarrhoeal disease, poor nutrient absorption, and stunting as well. While we know of no other studies of the association between women's empowerment and improved household WASH facilities and practices, our positive findings may be because an empowered mother has increased access to and decision-making around the use of financial resources, enabling the purchase of soap for handwashing, supplies to ensure toilet cleanliness or even WASH-related hardware such as toilets and safe drinking water. It may also be that empowered mothers have the time and decision-making autonomy to translate her knowledge into improved WASH practices, such as handwashing with soap and water, proper child stool disposal, and creating barriers between animals and the home.

Our findings also confirm the well-documented association between child DD and linear growth.(Jones et al., 2013) In Nepal, little improvement has been seen over time in complementary feeding practices: between 1996 and 2011, no more than 20% of children had adequate dietary diversity.(Cunningham, Headey, Singh, Karmacharya, & Rana, 2016; Ministry of Health and Popualation (MOHP) Nepal, 2012) We did not find an association between women's empowerment in agriculture and child DD. It is possible that the barriers to feeding young children a diverse diet are similar to those for WASH such as lack of time and money or incorrect knowledge and beliefs, but it is also possible that the barriers differ and that something beyond maternal empowerment is needed to overcome the barriers and improve child DD in this population. For instance, while knowledge barriers related to both diets and WASH exist, long-standing, food-related cultural taboos and beliefs including socially-accepted norms regarding which foods are good versus bad, for different types of people, during different seasons, etc. These complex belief patterns are not so rigid for use of soap or other WASH indicators and would require additional inputs such as well-designed and locally-relevant behaviour change communication strategies. Additionally, lack of food availability and accessibility may prevent the translation of empowerment into improved child dietary diversity in remote villages of Nepal with limited and perhaps seasonal access to markets. Travel to markets, cooking, and feeding a child all require substantial time and financial resources, whereas WASH products may be more readily available, cheaper, or not require as much of a time investment. For example, toilet materials are purchased once and cleaning supplies periodically whereas food purchases are required on a daily or weekly basis.

There are some limitations to this study. First, the 5DE variables used for the primary explanatory variables in the path analysis are binary variables with pre-set cut-offs determining if a woman is empowered in that dimension or not. These binary variables fail to capture more subtle variations across the population. There is also the potential for unobservable or unmeasured confounding factors in our analytical models. However, given our extensive literature review, familiarity with the context, and the rich household survey data, we are confident that our analyses controlled for the majority of potentially confounding factors at the child, maternal, and household levels. Another limitation is that many variables included in our models were based on self-reporting, with the

316 exception of child length, which was measured directly, and most of the household practices (or
317 proxy for practices) included in the WASH index, which were based on spot-check observations.
318 Self-reported practices may be subject to respondent reporting error or social desirability bias (e.g.
319 biasing response in favour of what is known to be optimal practice). This bias may mean that
320 certain known ideal practices, e.g. handwashing with soap, are actually worse than they appear,
321 but we do not expect influence our analytic models. Because calculation of LAZ requires child age
322 in days, precision in child date of birth is important. However, in our dataset a majority of the birth
323 dates came from maternal recall which could potentially result in measurement error. Finally, the
324 use of a cross-sectional dataset prevents us from assessing the direction of effects, but our
325 mediation models help to confirm our hypothesis on the temporality of factors analysed – that a
326 woman being empowered engages in optimal WASH practices, which in turn, influence her child's
327 nutritional status. The cross-sectional dataset also precludes exploration of seasonal variation,
328 known to be important in Nepal for many of the variables used in our analyses (e.g. WASH
329 facilities and practices, LAZ, and agricultural production). However, the focus on one particular
330 aspect of a woman's life – that of her productive activities in agriculture, by using the WEAI, the
331 first survey-based tool explicitly designed to capture the multi-dimensionality of empowerment and
332 assess empowerment in agriculture in developing countries, is an important addition to the
333 literature on women's empowerment and child nutrition in South Asia.
334
335 Additional research is needed to validate the findings from this study in diverse settings and
336 investigate what additional pathways may be mediating the association between women's
337 empowerment in agriculture and child nutritional status. Research is also needed to test and
338 validate indicators to characterize more accurately the different dimensions of optimal childcare,
339 feeding and hygiene practices during the first two years of a child's life.(M T Ruel, 2017) Finally,
340 additional research could shed light on how maternal caregiving resources other than women's
341 empowerment may help enable mothers to adopt recommended complementary feeding practices.
342 This is the first study to formally test the pathways through which women's empowerment in
343 agriculture contribute to improving child nutritional outcomes and to generate evidence on the
344 linkages between women's empowerment, WASH facilities and practices, and child nutrition. Our

findings also show that empowering women in Nepal is associated with better WASH facilities and practices, but is not sufficient to improve children's DD. Policies and programs should therefore prioritize women's empowerment as a key investment to improve women and children's well-being, but should also simultaneously tackle other key determinants of child undernutrition, such as poverty, food insecurity and lack of education.

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Conflict of interest statement

None declared.

Contributors' statement

K.C., S.K., P.M., and M.R. designed research; K.C. and S.K. conducted research; K.C., G.P. and E.F. analysed and/or interpreted the data; K.C. wrote paper and had primary responsibility for final

content. All authors provided feedback on various manuscript drafts and read and approved the final manuscript.

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Tables and Figures:

Table 1: Women's Empowerment in Agriculture Index: domains, indicators and definitions

Domain	Indicator	Definition of empowerment
Production	Input into productive decisions	A mother with at least some input into decisions, makes the decisions, or feels she could make the decisions if she wanted, in at least two agricultural production domains
	Autonomy in production	A mother who does not strongly disagree that her decisions related to at least one of agricultural production, taking crops to the market, or livestock raising, were externally motivated or coerced
Resources	Ownership of assets	A mother who solely or jointly owns at least one large or two small assets
	Right to purchase, sale, or transfer agricultural assets	A mother who has at least one joint right to purchase, sell, or transfer at least one large or two small household agricultural assets
	Access to and decisions on credit	A mother who has at least one source of formal or informal credit and makes at least one decision solely or jointly for at least one of these types of household credit
Income	Control over use of income	A mother with at least some input into decisions about income generated from household agricultural activities or feels she can make decisions in at least one major household income/expenditure domain
Leadership	Group membership	A mother who participates in at least one community group
	Speaking in public	A mother who has any degree of comfort when speaking in public in at least one of the three contexts asked about
Time	Workload	A mother who works no more than 10.5 hours a day including work as an employee; self-employed; in agricultural labor; and domestic work
	Leisure	A mother who does not express any dissatisfaction with the amount of time she has available for leisure activities

Table 2: Sample characteristics

Variables	N	Mean (SD)/ %
Child, maternal and household background chanracteristics		
Child sex: girls (0/1)	1402	49.9%
Age in completed months (range: 6.0-23.9)	1402	14.9 (5.2)
Maternal height in centimeters (range: 133-180)	1401	151.6 (5.5)
Maternal age in completed years (range: 15-52)	1402	25.1 (5.5)
Maternal years of schooling completed (range: 0-14)	1402	5.0 (4.2)
Maternal level of formal schooling	1402	
Less than grade one		31.7%
Some primary		14.0%
Completed primary (grades 1-5)		7.8%
Some secondary		25.5%
Completed secondary (grades 6-10)		11.1%
Completed class 12 or higher education		9.9%
Household wealth status (assets owned) (range: 0-63)	1402	18.0 (7.9)
Household more than one child under 5 years: (0/1)	1402	34.6%
Agro-ecological zone of residence	1402	
Mountains		25.1%
Hills		52.3%
Terai		22.6%
Outcome: child nutritional status		
Length-for-age Z-score	1396	-1.63 (1.2)
Stunting prevalence	1396	37.8%
Primary explanatory: Women's empowerment in agriculture	1015	
Empowered in overall WEAI 5DE index		8.6%
Empowered in specific indicators		
Input into production decisions		81.4%
Autonomy in production		30.2%
Ownership of assets		84.9%
Right to purchase, sale, or transfer agricultural assets		57.2%
Access to and decisions on credit		30.1%
Control over use of income		59.7%
Group membership		20.7%
Speaking in public		80.4%
Workload (<10.5 hours in paid and unpaid labour)		35.1%
Leisure (satisfaction with time available)		82.1%
Mediators: childcare practices		
Feeding	1402	
Average dietary diversity (7 food group scale)		3.3 (1.2)
Zero food groups		2.0%
One food group		3.6%
Two food groups		17.3%
Three food groups		31.5%
Four food groups		30.0%
Five food groups		13.1%
Six food groups		2.2%
Seven food groups		0.3%
Water, sanitation and hygiene practices (scale of 1-10)		
Average score on 10 point scale	1381	5.2 (2.4)
Improved source of drinking water	1402	88.5%
Drinking water pot covered (spot check observation)	1391	48.6%

Improved clean toilet at dwelling (spot check observation)	1402	27.3%
HH is open defecation free for children (<5y)	1402	49.6%
Appropriate disposal of child (<5y) stools	1401	52.5%
Dwelling free of animal and human faeces (spot check observation)	1402	44.4%
Water and soap/ash available at dwelling hand washing area (spot check observation)	1397	45.9%
Maternal recall of all 5 critical times for hand washing	1402	18.9%
Dwelling free of garbage (spot check observation)	1398	67.9%
No animals inside dwelling (spot check observation)	1400	71.5%

Table 3: Bivariate associations between indicators from the women's empowerment in agriculture index (WEAI) and Length-for-age Z-scores (LAZ) among children 6-24 months of age in rural Nepal

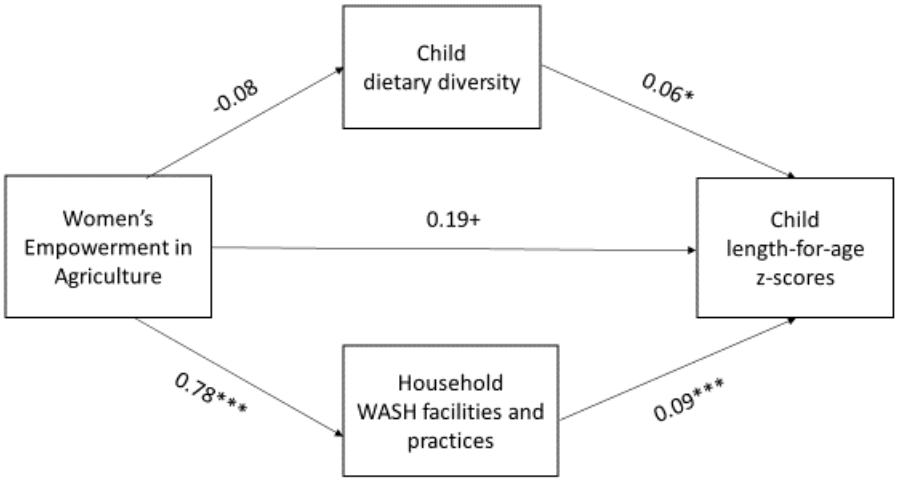
	Length-for-age Z-scores (N=1013)	
Women's Empowerment in Agriculture Index's (WEAI) Five Domains of Empowerment (5DE) Indicators	β	**P Value**
Aggregate WEAI 5DE	0.24	0.03
Input into productive decisions	0.01	0.92
Autonomy in production	0.19	0.02
Ownership of assets	0.00	0.98
Purchase, sale, or transfer of assets	-0.72	0.35
Access to and decisions about credit	0.17	0.03
Control over use of income	0.12	0.21
Group membership	0.03	0.81
Confidence speaking in public	0.05	0.60
Workload (>10.5 hours per day)	0.07	0.39
Leisure time satisfaction	0.33	0.001

Table 4: Standardised coefficient results for the path analysis of women's empowerment and child (6-24 month) Length-for-Age Z-scores (LAZ) via dietary diversity and water, sanitation and hygiene facilities and practices

	Outcome: LAZ		Mediator: Dietary Diversity		Mediator: WASH	
	β	P Value	β	P Value	B	P Value
Women's empowerment in agriculture (Aggregate WEAI 5DE)	0.19	0.08	-0.08	0.44	0.78	<0.001
Dietary diversity (range: 0-7 food groups)	0.06	0.05				
WASH (range: 0-10 key practices)	0.09	<0.001				
Child age in months (range: 6.0-23.9 months)	-0.13	<0.001	0.17	<0.001	<0.00	0.99
Child age squared	<0.00	0.02				
Child sex (male: yes/no)	0.15	0.01	0.07	0.37	0.09	0.41
Maternal height in centimeters (range: 133.2-179.6)	0.05	<0.001				
Maternal age in years (range: 15-52)	<0.00	0.58	<0.00	0.52	0.03	0.01
Maternal years of schooling (range: 0-20)	0.02	<0.001	0.04	<0.001	0.22	<0.001
Household wealth/asset ownership (range: 0-63)	0.01	0.07	0.01	0.08	0.02	0.01
Household under 5s (more than 1: yes/no)	-0.05	0.12	-0.10	0.12	-0.50	<0.001
Household altitude in meters (range: 60-3081)	<0.00	<0.001	<0.00	0.01	<0.00	<0.001
Breastfeeding status (presently: yes/no)	0.06	0.78	0.32	0.17		
Child illness (in last 2 weeks: yes/no)	-0.03	0.69	0.02	0.80		

Note: All models are adjusted and control for child sex and age; maternal age, height, and education; and household wealth status, number of children under five, and agro-ecological zone of residence, as well as district-level clustering.

Figure 2: Standardised associations for path analysis between Women's Empowerment in Agriculture and child (6-24m) Length-for-Age Z-Scores (LAZ) via child dietary diversity and household WASH facilities and practices



Note: +P<0.10, *P<0.05, ** P<0.01, *** P<0.001
Note: All models are adjusted for confounders and district-level clustering

Notes: * p ≤ 0.05, **p ≤ 0.001; All models are adjusted for covariates noted and controlled for district level clustering