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

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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 (<2 years) 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's Five Domains of Empowerment subindex. 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 nonempowered 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

child nutrition, dietary diversity, mediation, Nepal, WASH, women's empowerment

1 | 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 (Black et al., 2013). In Nepal, 36% of children under 5 years of age are 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 (Cunningham, Headey, Singh, Karmacharya, & Rana, 2016; Joshi, Agho, Dibley, Senarath, & Tiwari, 2012; Ministry of Health, 2017).

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 (Engle et al., 1999; UNICEF, 1990). Previous studies have documented positive associations between women's autonomy, control over resources, and other aspects of empowerment and child well-being (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, 2015; 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 (LAZ), weight-for-age, or weight-for-height/length *z*-scores (Begum & Sen, 2009; Desai & Johnson, 2005; Sethuraman, Lansdown, & Sullivan, 2006). Evidence relating the Women's Empowerment in Agriculture Index (WEAI; Alkire et al., 2013) itself to food security and health and nutrition outcomes is also emerging (Sraboni, Malapit, Quisumbing, & Ahmed, 2014; United States Agency for International Development, 2012). However, these prior studies have not investigated how and why these factors are associated, that is, what factors are part of the pathways between women's empowerment and child nutrition (Cunningham, Ploubidis, 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 Population (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 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 LAZ among children 0–24 months (Cunningham, Ploubidis, et al., 2015).

In this study, we expand our prior work to empirically test the pathways through which women's 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, 2004; Cumming & Cairncross, 2016; Onyango, Borghi, de Onis, Casanovas, & Garza, 2013), but empowerment may enable mothers to make better decisions regarding the foods they give to their children and the investments they make in WASH facilities, such as toilets and soap, or the behaviours they adopt. Prior work on intrahousehold dynamics suggests a positive association between women's control over resources and household health outcomes (Lépine & Strobl, 2013; Richards & Kim, 2011; Thomas, 1990).

Key messages

- In the context of rural Nepal, women's empowerment was positively associated with LAZ among children 6 to 24 months of age (β = 0.27, *P* = 0.03).
- Women's empowerment was also associated with water, sanitation, and hygiene facilities and practices and in turn with child LAZ; by contrast, child dietary diversity was not a mediating factor for 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 nutritional status in different contexts.

2 | METHODS

2.1 | Data source and study sample

We used data from a cross-sectional baseline survey of an evaluation of *Suaahara*, a USAID-funded multisectoral 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).

Multistage cluster sampling was used to select 4,080 households across 240 wards, each household with at least one child less than 5 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 (<5 years), households (*n* = 17 per ward) were randomly chosen. In households with more than one child (<5 years), 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 (6–24 months) of age (*n* = 1402), given that most growth faltering occurs during the first 2 years of life and that the complementary feeding pathway (DD) examined is relevant only for children 6 months of age or older who are consuming complementary foods (Ruel, 2010; WHO Expert Committee on Physical Status, 1995).

Trained enumerators (*n* = 70) fluent in the local languages conducted two household interviews, one with the index child's mother and one with the to a household member responsible for major household decision-making, with preference given first to the index child's father and second to another adult male. In cases where there was no man in the household, that interview was done with a female decision-maker, who could have been the mother of the child. 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 and health, and household access to information and 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 assess household construction, availability of toilets, and proxies for sanitation and hygiene practices such as availability of a handwashing station with soap and water. Both household interviews included an identical set of questions regarding empowerment in household agricultural activities.

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

2.2 | Measures and variables

2.2.1 | 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 g) and height/length boards (ShorrBoard produced by Weight and Measure LLC; precision ±0.1 cm). The average weight and height/length were calculated for use in data analysis. Child date of birth was noted from a birth certificate (n = 621; 44.3% of children 6–24 m) 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. 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 (n = 6; 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).

2.2.2 | Primary exposure—Women's empowerment in agriculture

The set of survey questions developed to construct the WEAI was used. The WEAI is composed of two subindexes: the five domains of empowerment (5DE) index (90% of the WEAI) and the gender parity index (10% of the WEAI; United States Agency for International Development, International Food Policy Research Institute, Development, & Oxford Poverty and Human Development Initiative, 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 (6–24 m). 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 questions on empowerment in agriculture, specifically related to the following 10 dimensions: (a) input into productive decisions; (b) autonomy in production; (c) asset ownership; (d) rights over assets; (e) access to and decision-making on credit; (f) control over the use of income; (g) membership in community groups; (h) comfort level speaking in public; (i) workload; and (j) 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 (Table 1). An individual is considered empowered in each of the 10 dimensions if she meets a minimum threshold (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 10 component indicators, with each variable representing empowerment in a specific dimension of women's empowerment in agriculture.

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 hr a day including work as an employee; self-employed; in agricultural labour; and domestic work
	Leisure	A mother who does not express any dissatisfaction with the amount of time she has available for leisure activities

2.2.3 | Mediators—DD and WASH practices

This survey included a 24-hr qualitative dietary recall of foods consumed in the previous day to assess the child's DD using the WHO/UNICEF indicator (WHO, 2010). Mothers were asked what they had given the child to eat or drink in the prior 24 hr and foods were grouped into the following categories: grains, pulses, animal flesh, eggs, vitamin A-rich fruits and vegetables, other fruits and vegetables, and dairy. We used the score (ranging from 0 to 7) as a continuous variable in our analyses.

To measure household WASH facilities and practices (or proxies for practices), we constructed 10 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):

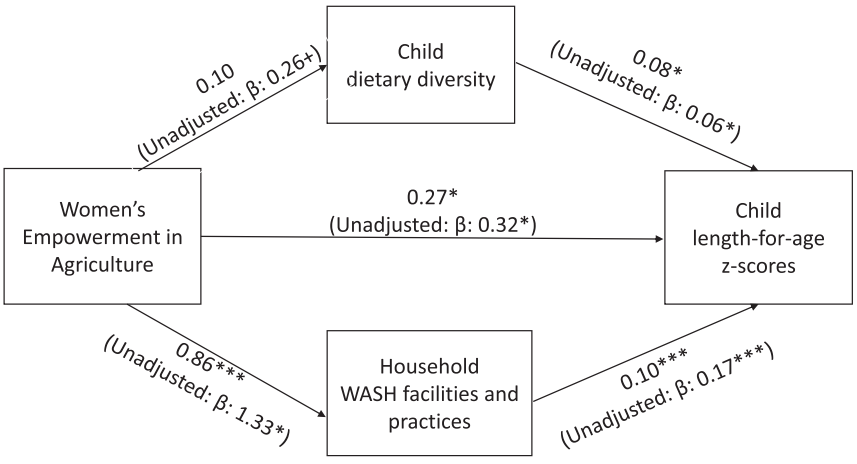
1. improved water source at the house including piped water into the dwelling, yard or plot, standpipe or public tap, a tubewell or borehole, protected well or bottled water;
2. drinking water pot covered or do not store water at household level;
3. household has a toilet that is clean;
4. house is free 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 (<5 years) do not defecate in the open;
9. proper disposal of child (<5 years) 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).

2.3 | 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 10 component indicators of women's empowerment in agriculture and child LAZ, using ordinary least squares multivariate regression models adjusted for potentially confounding child, maternal, and household factors as well as clustering. 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; Shroff, Griffiths, Adair, Suchindran, & Bentley, 2009; 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 5 years of age in our regression models. In the model testing DD as a mediator, we also controlled for breastfeeding



Note: +P<0.10, *P<0.05, ** P<0.01, *** P<0.001
Note: All models are adjusted for confounders, as noted in Table 4.

FIGURE 1 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

status and whether the child had been ill during the 2 weeks preceding the survey.

3 | RESULTS

3.1 | 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 1 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 three of seven food groups and their household engaged in about half of the 10 optimal WASH practices measured and included in the scale. Only about 9% of the mothers were categorized as empowered in agriculture, according to the WEAI 5DE. Among the 10 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 hr per day (35%).

3.2 | 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 ($\beta = 0.24$; $P < 0.05$), as previously documented for the whole sample of children 0–24 m ($\beta = 0.20$; $P < 0.05$; Cunningham, Ploubidis, 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 (6–24 m) LAZ: satisfaction with the amount of time she has to engage in leisure activities ($\beta = 0.33$; $P < 0.001$); autonomy in household production decisions ($\beta = 0.19$; $P < 0.05$); and ability to access and make decisions about household credit ($\beta = 0.17$; $P < 0.05$).

Both hypothesized mediating variables—WASH facilities and practices and child DD—were independently and positively associated with child LAZ (Table 4). A 1 *SD* increase in the WASH scale was associated with a 0.10 *SD* increase in child LAZ ($P < 0.001$). Similarly, a 1 *SD* increase in child DD was associated with a 0.08 *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, but was not significantly associated with child DD (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 1 *SD* improvement in women's empowerment in agriculture was associated with a 0.86 *SD* improvement in household WASH facilities and practices ($P < 0.001$) and a 1 *SD* improvement in household WASH facilities and practice was associated with a 0.10 *SD* improvement in child LAZ ($P < 0.001$ Figure 1).

4 | DISCUSSION

This study shows that in rural Nepal, women's empowerment in agriculture is associated with 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 subdomains 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, Ploubidis, et al., 2015).

WASH is a recognized determinant of child growth (Dangour et al., 2013). In Nepal, WASH 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 also persists in rural Nepal, increasing the risk of diarrhoeal disease, poor nutrient absorption, and stunting as well (Dangour et al., 2013; Mbuya & Humphrey, 2015). Although 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 their 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 support findings from other studies that have documented an 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 DD (Cunningham et al., 2016; Ministry of Health and Population (MOHP) Nepal, 2012). We did not find an association between women's empowerment in agriculture and child DD. It is possible that, in this context where financial resources are limited, women's empowerment is insufficient to ensure diverse diets for young children. It is also possible that DD measured during the previous 24 hr does not accurately reflect the quality of diets from birth until the time of measurement, and that this measurement issue weakens the potential strength of association between DD and child LAZ. This problem is less likely to occur for WASH outcomes, which may be less likely to change over a relatively short period (between the child's birth and study

TABLE 2 Sample characteristics

Variables	*N*	Mean (*SD*)/%
Child, maternal, and household background characteristics		
Child sex: Girls (0/1)	1,402	49.9
Age in completed months (range: 6.0–23.9)	1,402	14.9 (5.2)
Maternal height in centimetres (range: 133–180)	1,401	151.6 (5.5)
Maternal age in completed years (range: 15–52)	1,402	25.1 (5.5)
Maternal years of schooling completed (range: 0–14)	1,402	5.2 (4.2)
Maternal level of formal schooling	1,402	
Less than Grade 1		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)	1,402	18.0 (7.9)
Household more than one child under 5 years: (0/1)	1,402	34.6
Agro-ecological zone of residence	1,402	
Mountains		25.1
Hills		52.3
Terai		22.6
Outcome: Child nutritional status		
Length-for-age *Z*-score	1,396	−1.63 (1.2)
Stunting prevalence	1,396	37.8
Primary explanatory: Women's empowerment in agriculture	1,015	
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 hr in paid and unpaid labour)		35.1
Leisure (satisfaction with time available)		82.1
Mediators: Childcare practices		
Feeding	1,402	
Average dietary diversity (seven 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	1,381	5.2 (2.4)
Improved source of drinking water	1,402	88.5
Drinking water pot covered (spot check observation)	1,391	48.6
Improved clean toilet at dwelling (spot check observation)	1,402	27.3
HH is open defecation free for children (<5 years)	1,402	49.6
Appropriate disposal of child (<5 years) stools	1,401	52.5
Dwelling free of animal and human faeces (spot check observation)	1,402	44.4
Water and soap/ash available at dwelling hand washing area (spot check observation)	1,397	45.9
Maternal recall of all five critical times for hand washing	1,402	18.9
Dwelling free of garbage (spot check observation)	1,398	67.9
No animals inside dwelling (spot check observation)	1,400	71.5

measurement). Finally, it may be that cultural taboos and beliefs regarding appropriate foods for young children are more constraining than belief patterns related to the use of soap and other WASH behaviours 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

TABLE 3 Associations between indicators of women's empowerment in agriculture and length-for-age z-scores among children 6–24 months of age in rural Nepal

Length-for-age *Z*-scores (*N* = 1013)				
WEAI's 5DE indicators	**β**	***P* value**	**95% confidence interval**	**R^2**
Aggregate WEAI 5DE	0.24	0.03	(0.03, 0.44)	0.24
Input into productive decisions	0.01	0.92	(−0.23, 0.26)	0.24
Autonomy in production	0.19	0.02	(0.03, 0.35)	0.24
Ownership of assets	0.003	0.98	(−0.38, 0.39)	0.24
Purchase, sale, or transfer of assets	−0.72	0.35	(−0.23, 0.09)	0.24
Access to and decisions about credit	0.17	0.03	(0.02, 0.31)	0.24
Control over use of income	0.12	0.21	(−0.07, 0.31)	0.24
Group membership	0.03	0.81	(−0.22, 0.28)	0.24
Confidence speaking in public	0.05	0.60	(−0.16, 0.27)	0.24
Workload (>10.5 hr per day)	0.07	0.39	(−0.07, 0.08)	0.24
Leisure time satisfaction	0.34	0.001	(0.16, 0.52)	0.25

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. WEAI: women's empowerment in agriculture index; 5DE: five domains of empowerment.

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)	0.27	0.03	0.10	0.41	0.86	<0.001
Dietary diversity (range: 0-7 food groups)	0.08	0.01				
WASH (range: 0-10 key practices)	0.10	<0.001				
Child age in months (range: 6.0-23.9 months)	-0.09	0.02	0.08	<0.001	<0.00	0.62
Child age squared	<0.00	0.49				
Child sex (male: yes/no)	0.21	0.002	0.10	0.15	0.15	0.23
Maternal height in centimeters (range: 133.2-179.6)	0.05	<0.001				
Maternal age in years (range: 15-52)	<0.00	0.41	<0.00	0.82	0.03	0.01
Maternal years of schooling (range: 0-20)	0.05	0.01	0.05	<0.001	0.22	<0.001
Household wealth/asset ownership (range: 0-63)	0.01	0.09	0.01	0.05	0.03	<0.001
Household under 5s (range: 1-2)	-0.08	0.29	-0.20	0.01	-0.42	<0.001
Household altitude in meters (range: 60-3081)	<0.00	<0.001	<0.00	0.06	<0.00	<0.001
Breastfeeding status (presently: yes/no)	0.08	0.39	0.32	0.75		
Child illness (in last 2 weeks: yes/no)	0.03	0.39	-0.13	0.08		

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 altitude (to approximate agro-ecological zone of residence using a continuous variable).

the translation of empowerment into improved child DD 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 preset 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. Second, the 24-hr recall period for the measurement of DD fails to characterize usual diets; and the DD indicator has its limitations because it does not provide quantitative information on dietary intake. Third, as in most analytical models, there is the potential for unobservable or unmeasured confounding factors, as well as potential interactions between the exposure and mediator variables, two major challenges for mediation analysis (Vanderweele, 2012). 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 of the variables included in our models were based on self-reporting. Many of the variables included in the WASH index were also based on spot-check observations, which measure "proxies" for practices rather than the practices themselves. Self-reported practices may be subject to respondent reporting error or social desirability bias (e.g., biasing response in favour of what is known to be optimal practice). This bias may mean that certain known ideal practices, for example, handwashing with soap, are actually worse than what our study finds, but we do not expect that this affects our analytic models. Because calculation of LAZ requires child age in days, precision in child date of birth is important. However, in our dataset, a majority of the birth dates came from maternal recall that could potentially result in measurement error. Another limitation is that the use of a cross-sectional dataset prevents us from assessing the direction of effects and

precludes exploration of seasonal variation, known to be important in Nepal for many of the variables used in our analyses (e.g., WASH facilities and practices, LAZ, and agricultural production). Finally, as mediation analysis was not a part of the study design or power calculations, the study may be under powered to detect the relationships we are testing. However, the focus on one aspect of a woman's life—that of her productive activities in agriculture, by using the WEAI, the first survey-based tool explicitly designed to capture the multidimensionality of empowerment and assess empowerment in agriculture in developing countries—is an important addition to the literature on women's empowerment and child nutrition in South Asia.

Additional research is needed to validate the findings from this study in diverse settings and investigate what additional pathways may be mediating the association between women's empowerment in agriculture and child nutritional status. Research is also needed to test and validate indicators to characterize more accurately the different dimensions of optimal childcare, feeding and hygiene practices during the first 2 years of a child's life (Ruel, 2017). Additional research could shed light on how maternal caregiving resources other than women's empowerment may help enable mothers to adopt recommended complementary feeding practices. Further research should also explore whether seasonality influences the associations documented in our study, which was conducted during the rainy season.

This is the first study to formally test the pathways through which women's empowerment in agriculture contributes to improving child nutritional outcomes and to generate evidence on the 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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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

CONTRIBUTIONS

KC, SK, PM, and MR designed research; KC and SK conducted research; KC, GP, and EF analysed and/or interpreted the data; KC 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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