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## Nourishing Hope? Changes in Malnutrition and Changes in Girls' Aspirations—Evidence From the *Suaahara II* Adolescent Girls Panel in Nepal

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### A B S T R A C T

**Purpose:** Malnutrition is a pressing public health challenge in South Asia with adverse consequences for adolescent girls' well-being and, potentially, aspirations as drivers of developmental progress. This study aimed to investigate associations between changes in malnutrition and changes in girls' aspirations in key life domains.

**Methods:** We analyzed two-period panel data from the *Suaahara II* Adolescent Girls Panel (10–19 years) in Nepal (2018–2019, n = 613). Height, weight, blood samples, 24-hour dietary recalls, and indicators of girls' educational, occupational, marital, and fertility aspirations were collected. Height-for-age z-scores, body mass index-for-age z-scores, hemoglobin concentration (Hb g/dL), and dietary diversity scores for women were calculated. Through cluster-robust fixed-effects regressions, we examined whether changes in thinness (body mass index-for-age z-scores < -2 standard deviation), anemia (Hb <115 g/L nonpregnant <11 years; Hb <120 g/L nonpregnant >12 years; Hb <110 g/L pregnant), and reaching minimum dietary diversity for women were associated with changes in educational, marital, or fertility aspirations.

**Results:** A change from thinness to no thinness increased girls' aspired ages of having a first child by 2.77 years (standard error [SE] 1.22, p = .025). A change from anemia to no anemia increased girls' aspired years of education by .54 (SE .27, p = .044). This association was stronger for post-menarche girls (b -.62, SE .29, p = .035). No associations were found between changes in minimum dietary diversity for women and any of the aspirations.

**Conclusions:** Thinness and anemia were negatively associated with adolescent girls' aspirations in domains of fertility and education. Multisectoral integrated policies and programs that improve adolescent nutritional status and diets have the potential to foster adolescent girls' aspirations and thereby increase their future potential.

### IMPLICATIONS AND CONTRIBUTIONS

Findings of this study imply that investments in adolescent girls' nutrition and diets would foster their aspirations and development. Findings revealed: negative associations between thinness and anemia and adolescent girls' fertility and educational aspirations, respectively; and positive associations between height-for-age and educational aspirations, and hemoglobin and occupational and fertility aspirations.

**Conflicts of interest:** The authors have no conflicts of interest to disclose.

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Investing in adolescent health has the potential to generate a triple dividend for today's adolescents, their future, and the next generations through social, economic, and demographic benefits [1]. Adolescence (ages 10–19 years) is characterized by rapid biological, physical, and psychosocial growth and social status changes [2]. During early adolescence (10–14 years), body mass increases, alongside physiological and behavioral changes, whereas late adolescence (15–19 years) is characterized by further growth and brain development. Because of increased nutritional requirements during the onset of puberty and the accompanying growth spurt, adolescence is an important window of opportunity to maintain, reverse, or recover from nutritional and growth deficits [3,4].

Adolescent malnutrition persists as a public health challenge in low-income contexts like South Asia. Adolescent girls are particularly vulnerable, yet largely overlooked in nutrition programming. About one in 10 is stunted, one in three is underweight, and more than half are anemic [5]. Adolescent malnutrition has been associated with, inter alia, adverse outcomes in cognition, human capital, schooling, earnings, and economic productivity [6]. However, little attention has been paid to its connection with well-being and noncognitive outcomes. Adolescence is also a pivotal time for the formation of aspirations. Aspirations, future-oriented desires for one's possible self, steer behavior and intentions, and have been shown to be of vital importance for future outcomes and human potential [7]. A lack of aspirations can lower investment in one's future-oriented behavior or, when the gap between one's aspirations and current status becomes too wide, can foster a fatalistic attitude, that in turn serves to sustain or reinforce poverty [8].

Aspirations are dynamically influenced by a multitude of factors, such as one's self-efficacy, age, household wealth, geographic location, sociocultural context, and the influence of others [7]. Only a few studies have specifically investigated associations between malnutrition and adolescent aspirations. These studies primarily focused on childhood height-for-age in relation to adolescent educational aspirations [9,10]. For instance, in India's Andhra Pradesh, a longitudinal study showed that childhood height-for-age scores at ages seven and eight were positively associated with adolescents' educational aspirations at age 11–12 years: every standard deviation (SD) increase in the height-for-age z-score (HAZ) increased educational aspirations by 5.1% [10]. In an experimental study involving iron supplementation to reduce anemia among school-going adolescents in Cajamarca, Peru, aged 11–19 years ( $n = 219$ ), iron supplementation resulted in a 16 percent increase in adolescents' educational aspirations and perceived upward mobility [11]. In Australia, greater weight and specifically overweight were inversely associated with work-related aspirations, lack of marital aspirations and reproductive aspirations, and lower educational aspirations among young women aged between 18 and 23 years ( $n = 7,815$ ) [12].

While current research is mostly focused on socioeconomic or psychological influences on aspirations, studies from low-income contexts also imply a causal effect of malnutrition on

aspirations. However, without longitudinal data on aspirations as well as nutritional and dietary indicators, this remains unknown. To the best of our knowledge, there has been no research in a low-income context investigating associations between adolescent malnutrition and aspirations over time in multiple key life domains including education, occupation, and family formation. This study therefore aims to investigate the associations and changes over a one-year period between adolescent girls' nutritional and dietary diversity indicators and their aspirations in the domains of education, occupation, marriage, and fertility.

## Methods

### Data source and participants

We used data from the Adolescent Girls Panel, collected under *Suaahara II*, a USAID-funded integrated nutrition program in Nepal. The surveyed areas represent 42 program districts of Nepal's 77 districts. In 2017, multistage cluster sampling was used for the *Suaahara II* monitoring survey, in which 1,093 adolescent girls and mothers participated. Since 2017, these adolescent girls have been followed annually (except for 2020 due to the COVID-19 pandemic). For a detailed overview of the sampling methods, we refer to Cunningham et al. [13]. For this study, we used the 2018 and 2019 panel data. Unlike in 2017, in 2018 and 2019, adolescent girls' aspirations in several life domains as well as 24-hour dietary recall data, anthropometry (height and weight), and hemoglobin (Hb) concentration were measured, in addition to a range of demographic and socioeconomic factors. Surveys were conducted by trained female enumerators and standardized anthropometrists, using pilot-tested, (back)translated questionnaires programmed on mobile phones. Prior informed consent was obtained, as well as parental assent for girls under 16 years of age. Ethical approval was obtained from the Nepal Health Research Council (No. t97/ZO1B).

In 2018 and 2019, 975 and 958 girls, respectively, of the initial 1,093 girls participated in the survey, representing attrition rates of 10.8% and 12.4%, respectively. For analyses, we only included girls who participated in both years and who were still classified as an adolescent in 2019 according to the World Health Organization (WHO) definition, thus aged between 10 and 20 years (228 months) ( $n = 675$ ). We further restricted our analyses to observations with complete data on nutritional indicators and data relevant to each type of aspiration: only school-going girls for educational aspirations ( $n = 559$  in 2018 and  $n = 531$  in 2019), occupational aspirations ( $n = 613$  in both years), only unmarried girls for marital aspirations ( $n = 534$  in 2018 and  $n = 526$  in 2019), and only those without children for fertility aspirations ( $n = 324$  in 2018 and  $n = 364$  in 2019).

### Measures

**Aspirations.** Aspiration indicators were adapted from other tools and studies [14–16]. Educational aspirations were measured by asking school-going girls to report their future aspired level of education, which was then converted into aspired years of

education. “I do not know” answers were converted into current year of schooling ( $n = 13$  in 2018 and  $n = 15$  in 2019). Occupational aspirations were measured by girls’ reporting of their aspired future jobs and then classified based on the skill level [1–4] required, according to the Nepal Standard Classification of Occupation [17]. A binary variable was created for no/low-skill (0–2) versus a higher-skilled job (3 or 4). “I do not know” answers were classified as (0–2), assuming low aspirations ( $n = 37$  in 2018 and  $n = 11$  in 2019). Marital aspirations were measured by aspired year of marriage, of unmarried girls only. We used age in years as a continuous outcome and excluded all “I do not know” responses ( $n = 48$  in 2018 and  $n = 26$  in 2019). Fertility aspirations were measured by girls’ aspired age of having a first child, only among girls without children. “I do not know” or “do not want” responses were excluded from the analyses ( $n = 318$  in 2018 and  $n = 253$  in 2019).

**Nutritional and dietary diversity indicators.** Height was measured using a standard ShorrBoard. Weight was measured with an electronic on-site calibrated SECA digital scale. Both measurements were taken twice, and an average was used to increase precision. Height and weight measurements were converted into HAZ and body mass index–for-age z-scores (BAZ) using WHO AnthroPlus software. Next, HAZ and BAZ were dichotomized based on the 2007 WHO growth reference cutoff values, into stunted (HAZ <  $-2$  SD = 1) or thin (BAZ <  $-2$  SD = 1) [18]. Measures of high BAZ or overweight were not included in this study, as the prevalence of overweight among adolescent girls in Nepal is very low: 2.6% in our sample [13]. Hb concentration was measured using the HemoCue Hb-301 photometer and corrected for altitude, measured using GPS (Garmin eTrex 30x). A binary variable was created to indicate anemia, based on the WHO anemia cutoff values: nonpregnant girls up to 11 years (Hb < 115 g/L), nonpregnant girls 12 years and older (Hb < 120 g/L), or pregnant girls (Hb < 110 g/L) [19]. The dietary diversity score for women (DDS-W) was calculated based on an open-ended 24-hour dietary recall [20]. Consumed food items were grouped into 10 groups to calculate DDS-W: grains, white roots and tubers, and plantains; pulses (beans and lentils); nuts and seeds; dairy; meat, poultry, and fish; eggs; dark-green leafy vegetables; vitamin-A-rich fruits and vegetables; other vegetables; other fruits. A binary variable was then created to denote whether girls obtained minimum dietary diversity (for women, MDD-W) defined as having consumed foods from at least five of the 10 food groups [20].

**Control factors.** Potentially confounding factors were also included, such as adolescent girls’ age (in completed years), marital status for occupational aspirations (0/1), school enrollment (0/1, not for educational aspirations), and her highest educational level reached (in years). Individual self-efficacy scores (0–40), measured with the eight-item New General Self-Efficacy Scale [21], were included. This scale measures the extent to which an adolescent believes she is capable to assert influence over her own life and has been associated with aspirations [22]. The scale was reliable for both periods ( $\alpha = .81$ ,  $\alpha = .80$ , resp.). Relative household wealth, categorized in five wealth quintiles (highest through lowest) [23], was calculated from the sum of a household’s owned goods (television, cupboards, tables, fans), cooking energy source, and the quality of roof, floor, and

wall materials. Household size (number of members), caste/ethnicity (*Brahmin/Chhetri*, socially excluded, and others), agro-ecological zone of residence (lowland plains [*Terai*], hills, mountains), and the household head’s education (in completed years) were also included. Menarche status (whether a girl has started menstruating = 1) was included as an indicator of the pubertal stage.

### Data analysis

Statistical analyses were conducted with Stata SE v.15. Descriptive analyses were first conducted to describe the following: sample means, SD sociodemographic factors, and proportions for all nutritional and dietary diversity indicators and aspirations, with differences over time, tested using a paired t-test and McNemar’s test for nutritional, dietary diversity, and aspiration indicators (Table 1). Preliminary analyses (presented in Appendix A, tables A1 and A2) assessed cross-sectional associations between HAZ, BAZ, Hb, and DDS-W and aspirations, through two-stage hierarchical binary logistic regressions for occupational aspirations, reported as adjusted odds ratios, and linear regressions for educational, marriage, and fertility aspirations, reported by unstandardized ( $b$ ) and standardized ( $\beta$ ) betas, for both periods separately. We reported both standardized coefficients, which represent the differences in outcomes for an SD difference in the predictor variables and thus allow for comparison within models, and unstandardized coefficients, which facilitate comparison between models. Adjusted  $R^2$  scores were compared to see whether the addition of nutritional indicators contributed to improved models. All assumptions, including those of multicollinearity, were met.

The main analyses presented in this study—associations between changes in malnutrition and changes in aspirations—include cluster-robust, two-period (2018–2019), fixed-effects, linear regressions, under the assumption that our nutritional predictors of interest and aspirations showed some variation over time [24]. We excluded stunting as an indicator because catch-up growth is less likely over the course of one year [25] and data showed no significant changes between HAZ means or stunting prevalence over time. Moreover, preliminary analyses showed minimal changes in occupational aspirations as an outcome. In our main models, we therefore only included the binary variables thinness, anemia, and MDD-W for the prediction of educational, marital, and fertility aspirations. Time-invariant covariates included in analyses were as follows: caste/ethnicity, household head highest level of education, and agro-ecological zone of residence, and time-variant covariates included a girl’s age, self-efficacy score, education years reached, menarche status, school status, marital status, maternal status, household wealth, and household size. As the relationships among the predictors are complex, we conducted sensitivity analyses (available on request) by estimating models with thinness, anemia, and MDD-W as individual predictors. Results in terms of significance levels and effect sizes were similar to the presented combined models. Standard errors were adjusted for clustering at the primary sampling unit. Statistical significance was considered at  $p < .05$ ,  $p < .01$ , and  $p < .001$  levels. Pregnant girls were excluded from any analysis involving thinness ( $n = 10$  in 2019 only).

**Table 1**  
Sample description and differences between the two years

	2018		2019		Difference (2018–2019)	
	n	Mean (SD) or % (n)	n	Mean (SD) or % (n)	n	Difference in mean or % (p value)
<b>Aspirations (outcome)</b>						
Aspired years of education	559	14.2 (2.79)	531	14.8 (2.53)	528	.63 (.000)
Aspired job: professional (vs. no/low-skilled)	613	75.7 (464)	613	71.6 (439)	613	4.07 (.039)
Aspired age of first marriage	534	22.2 (2.28)	526	22.7 (2.52)	492	.52 (.000)
Aspired age of first child	324	24.3 (2.54)	364	24.9 (3.03)	231	.52 (.049)
<b>Nutritional indicators (predictors)</b>						
Height-for-age z-score (HAZ)	613	−1.45 (.92)	613	−1.45 (.86)	613	.00 (.68)
BMI-for-age z-score (BAZ)	613	−.78 (.99)	603	−.70 (1.02)	603	.08 (.000)
Stunted (HAZ < −2 SD)	613	27.90 (171)	613	26.75 (164)	613	1.15 (.25)
Thin (BAZ < −2 SD)	613	11.75 (72)	603	10.61 (64)	603	1.14 (.16)
Adjusted hemoglobin concentration (g/dL)	613	12.61 (1.37)	613	12.65 (1.27)	613	.04 (.36)
Anemic	613	27.90 (171)	613	24.80 (152)	613	3.10 (.11)
Dietary diversity score (range: 0–10)	613	4.2 (1.17)	613	4.4 (1.25)	613	.18 (.0031)
Not obtained minimum dietary diversity (<5/10 food groups) (vs. MDD-W)	613	60.52 (371)	613	54.98 (337)	613	5.5 (.031)
<b>Time-varying covariates</b>						
Age in years	613	13.8 (2.07)	613	14.8 (2.06)	613	1.0 (.000)
Self-efficacy total score	613	30.72 (4.68)	613	31.49 (4.44)	613	.77 (.000)
Education years reached	613	7.7 (2.16)	613	8.5 (2.21)	613	.8 (.000)
Postmenarche (vs. premenarche)	613	60.4 (370)	613	78.0 (478)	613	17.6 (.000)
School-going (vs. out-of-school)	613	91.2 (559)	613	86.6 (531)	613	4.6 (.000)
Married (vs. unmarried)	613	5.6 (34)	613	10.3 (63)	613	4.7 (.000)
Mother (vs. not a mother)	613	4.1 (25)	613	4.9 (30)	613	.8 (.000)
Pregnant (vs. not pregnant)	613	0 (0)	613	1.6 (10)	613	1.6 (.002)
Household wealth quintiles						(.002)
Lowest	613	18.60 (114)	613	17.46 (107)	613	1.14
Second lowest	613	25.61 (157)	613	22.68 (139)	613	2.93
Middle	613	25.29 (155)	613	22.35 (137)	613	2.97
Second highest	613	23.65 (145)	613	27.08 (166)	613	3.43
Highest	613	6.85 (42)	613	10.44 (64)	613	3.59
Household size (total number of members)	613	6.3 (2.89)	613	6.0 (2.78)	613	.3 (.00)
<b>Time-invariant covariates</b>						
<b>Caste/ethnicity</b>						
Brahmin/Chhetri	613	52.0 (240)	613	52.0 (240)	613	NA
Socially excluded	613	33.9 (319)	613	33.9 (319)	613	NA
Others	613	8.8 (54)	613	8.8 (54)	613	NA
Household head highest completed years of education	613	3.9 (4.11)	613	3.9 (4.11)	613	NA
<b>Agro-ecological zone of residence</b>						
Mountains	613	15.0 (92)	613	15.0 (92)	613	NA
Hills	613	51.1 (313)	613	51.1 (313)	613	NA
Lowland plains ( <i>Terai</i> )	613	33.9 (208)	613	33.9 (208)	613	NA

Data are expressed as means with SD in parentheses. Differences in means or proportions between the two time periods were tested with paired *t*-tests and Mc Nemar's test for significance (*p* values displayed).

BMI = body mass index; MDD-W = minimum dietary diversity women; NA = not applicable; SD = standard deviation.

## Results

### Sample descriptives

Table 1 provides an overview of girls' aspirations, nutritional indicators, and sociodemographic covariates in 2018 and 2019. Girls' mean age was 13.8 years in 2018 and 14.8 years in 2019. Between the two years, the proportion of girls enrolled in school dropped from 91.2% to 86.6%, and the mean years of schooling increased from 7.7 years to 8.5 years. The proportion of married girls increased to 10.3%, and five girls became mothers, increasing the percentage of mothers to 4.9% in 2019. In 2019, 10 girls were pregnant, and the proportion of postmenarche girls increased from 60.4% to 78.0%. Half of the girls belonged to the *Brahmin/Chhetri* ethnic/caste group, 39.2% belonged to the socially excluded ethnic/caste group, and the remainder belonged to other ethnic/caste groups. Most girls lived in the hills, 15.1% of girls lived in the mountains, and one third lived in the *Terai*. The

mean total self-efficacy score (0–40) increased from 30.72 to 31.49, and the total household size dropped from 6.3 to 6.0.

### Associations between nutritional and dietary diversity indicators and girls' aspirations

Results from the cross-sectional regression models for the prediction of educational, occupational, marital, and fertility aspirations, for 2018 and 2019 separately, are presented as supplementary materials in Appendix A (Tables A1 and A2). Findings from these models showed that in 2019, every SD increase in HAZ was associated with a .29 (one third of a year) ( $p = .027$ ) increase in aspired years of education. Hb was positively associated with occupational aspirations: with every unit (g/dL) increase in Hb in 2019, the odds of aspiring for a professional skilled job were 1.20 higher ( $p = .036$ ). In 2019, Hb was positively associated with fertility aspirations. With every unit increase in Hb, girls' aspired age of having a first child increased with .41 years ( $p = .0020$ ).

**Table 2**  
Main effects of malnutrition on educational, marital, and fertility aspirations

	Aspired years of education		Aspired age of first marriage		Aspired age of first child	
	b (SE)	p	b (SE)	p	b (SE)	p
Thinness (BMI-for-age z-score/BAZ) <sup>a</sup>						
Not thin (BAZ > -2 SD)	ref	NA	ref	NA	ref	NA
Thin (BAZ < -2 SD)	.31 (.73)	.67	-.50 (.74)	.50	-2.77 (1.22)	.025
Anemia <sup>b</sup>						
Not anemic	ref	NA	ref	NA	ref	NA
Anemic	-.54 (.27)	.044	.17 (.23)	.46	.29 (.34)	.40
MDD-W						
Obtained MDD-W	ref	NA	ref	NA	ref	NA
Not obtained MDD-W	-.15 (.20)	.44	-.24 (.19)	.20	-.09 (.26)	.72
Age in years	.41 (.23)	.080	.39 (.25)	.11	.85 (.26)	.0020
Self-efficacy total score	.01 (.03)	.74	.03 (.03)	.26	-.01 (.04)	.74
Education years reached	.00 (.16)	1.00	.03 (.22)	.89	-.28 (.16)	.089
Menarche status						
Not reached (pre) menarche	ref	NA	ref	NA	ref	NA
Reached (post) menarche	.66 (.30)	.030	.14 (.29)	.64	-.18 (-.40)	.66
School status						
Out-of-school	NA	NA	ref	NA	ref	NA
School-going	NA	NA	.04 (.58)	.95	1.52 (.53)	.0040
Household wealth quintiles						
Lowest quintile	ref	NA	ref	NA	ref	NA
Second lowest quintile	.06 (.34)	.85	.06 (.32)	.85	.39 (.43)	.37
Middle quintile	.02 (.41)	.96	.04 (.45)	.94	.36 (.73)	.62
Second highest quintile	.32 (.49)	.51	.17 (.49)	.73	.58 (.82)	.48
Highest quintile	-.06 (.57)	.91	.12 (.64)	.85	.80 (.86)	.36
Household size (total number of members)	.00 (.09)	.99	-.06 (.07)	.38	-.03 (.09)	.74
Caste/ethnicity						
Socially excluded	ref	NA	ref	NA	ref	NA
Brahmin/Chhetri	Omitted	NA	Omitted	NA	Omitted	NA
Others	Omitted	NA	Omitted	NA	Omitted	NA
Household head's highest completed years of education	Omitted	NA	Omitted	NA	Omitted	NA
Agro-ecological zone of residence						
Lowland plains ( <i>Terai</i> )	ref	NA	ref	NA	ref	NA
Hills	Omitted	NA	Omitted	NA	Omitted	NA
Mountains	Omitted	NA	Omitted	NA	Omitted	NA
Constant	8.16 (2.61)	.002	16.03 (2.68)	<.000	13.89 (4.22)	.001
R <sup>2</sup>	.70	NA	.73	NA	.84	NA
R <sup>2</sup> -adj.	.36	NA	.39	NA	.48	NA
F/Wald chi <sup>2</sup>	(12,178) = 2.37		(13,179) = 2.23		(13,171) = 2.54	
Prob > chi <sup>2</sup>	p = .008	NA	p = .010	NA	p = .003	NA
Observations	1,087	NA	1,060	NA	680	NA
No. of groups	562	NA	568	NA	452	NA

Main effects for educational, marital, and fertility aspirations are presented. Standard errors (SEs) were adjusted for clustering at the primary sampling unit (PSU). BMI = body mass index; MDD-W = minimum dietary diversity women; NA = not applicable; SR = standard error.

<sup>a</sup> Pregnant girls were excluded from any analysis involving thinness ( $n = 10$  in 2019 only).

<sup>b</sup> Anemia classification was based on the WHO anemia cut-off values: nonpregnant girls up to 11 years (Hb <115 g/L), nonpregnant girls 12 years and older (Hb <120 g/L), or pregnant girls (Hb <110 g/L) [13]. Minimum dietary diversity women (MDD-W) obtained when a girl consumed  $\geq 5/10$  food groups.

None of the nutritional predictors were associated with girls' aspired age of having a first child in 2018.

#### Changes in malnutrition and changes in girls' aspirations

Table 2 presents results from our fixed-effects models for educational, marital, and fertility aspirations. For our main analyses, we were interested in whether a shift from thinness, anemia, or not having obtained the MDD-W to no thinness, nonanemic, or having obtained MDD-W, respectively, was associated with higher aspired years of education, first age of getting married, or having a first child.

Among school-going girls, a change from being anemic to not being anemic was significantly associated with a half-year ( $b = -.54, p = .044$ ) increase in aspired years of education. The model showed no main effects of thinness or MDD-W on educational aspirations. In addition, a change from premenarche to postmenarche was associated with more than a half-year of

aspired education ( $b = .66, p = .030$ ). For marital aspirations, none of the nutritional indicators—thinness, anemia, or MDD-W—nor any of the socioeconomic and demographic factors significantly predicted a change in a girl's aspired age of first marriage. However, among girls without children and with known fertility aspirations, a change from being thin to not being thin was associated with an increase in the aspired age of having a first child by almost three years ( $b = -2.77, p = .025$ ). Neither anemia nor MDD-W was associated with girls' fertility aspirations. However, age ( $b = .85, p = .0020$ ) and school status ( $b = 1.52, p = .0040$ ) were both positively associated with girls' aspired ages of having a first child.

#### Anemia and educational aspirations by pubertal stage

Because a change in menarche status was significantly associated with a change in a girl's aspired years of education and the likelihood of anemia in Nepal is higher among older

(15–19 years) adolescent girls, possibly due to increased iron requirements and blood loss associated with menarche [26], we conducted an additional analysis to test if the positive effect of anemia on educational aspirations (only) differed by menarche status. The fixed-effects models for premenarche versus postmenarche girls are presented as supplementary materials in Appendix B (Table B1). The estimates for the postmenarche group showed a significant main effect of anemia on educational aspirations ( $b = -.62, p = .035$ ), whereas no main effects of anemia on educational aspirations were found in the premenarche group.

## Discussion

This study aimed to study the associations between nutritional and dietary diversity indicators and adolescent girls' aspirations in Nepal and investigated if changes in thinness, anemia, and MDD-W during adolescence were associated with changes in girls' aspirations. First, the panel models showed that girls who recovered from anemia between 2018 and 2019 reported higher educational aspirations in 2019. The disaggregated analyses for educational aspirations by menarche status showed that this finding was stronger for girls who had already entered puberty (as indicated by menarche) than that for those who were in the prepubertal stage. Second, findings showed that those who recovered from thinness reported higher aspired ages of having a first child.

Current evidence shows that iron, a building block of Hb, is crucial for brain development [27]. Although anemia is caused by a range of proximal as well as underlying factors including increased iron requirements, low dietary intake, infections, and inflammation, in Nepal, iron deficiency remains a major cause of anemia, especially among girls [26]. Although most studies have focused on the effects of anemia on the socio-emotional or cognitive outcomes of infants, some studies have found positive relations between Hb and other phenomena including less anxiety, less depression, and less grade repetition in adolescence [28]. The mechanism between anemia and aspirations may thus be moderated through other psychosocial influences or potential stress levels. Therefore, in further analyses, we added adolescents' total stress score to the models (available on request). This addition, however, did not significantly change the panel models, nor did it affect the findings on the associations between changes in malnutrition and changes in aspirations. Future research would benefit from including indicators of depression or anxiety. Nevertheless, findings underscore the importance of addressing anemia, whatever its cause, as it is a persisting problem in the context of Nepal, particularly among postmenarche adolescent girls [26]. In addition, cross-sectional findings showed that Hb was positively associated with occupational aspirations: girls with lower Hb concentration were more likely to aspire to no-skill or low-skill jobs, compared with a job requiring higher education or professional skills, and had lower aspired ages for having a first child. This is particularly interesting as it has been argued that well-nourished girls are more likely to delay marriage and thus their first pregnancy [29]. Hb increases can raise adolescent girls' aspirations, which can potentially result in better development outcomes. Future research, which includes specific indicators of iron-deficiency anemia (i.e., ferritin concentration), should further explore associations between changes in adolescent girls' diets to overcome anemia (if caused

by poor diets) and thus investigate the mechanisms behind the relationship between anemia and aspirations.

Findings also suggest that thinness was associated with fertility aspirations. Although this association is not directly obvious, as nutritional status can affect aspirations through several biological and social pathways, the fixed-effects models predicted that recovery from thinness was associated with an increased aspired age for having a first child. Generally, early marriage is associated with early childbearing, lower educational attainment, and school dropout in Nepal [30]. Evidence from 23 countries in sub-Saharan Africa showed that early marriage was associated with lower risks of being underweight. In South Asia, however, this is less plausible insofar as differing socio-cultural norms that discriminate against women and girls may in fact lead to the opposite outcome [31]. One possible mechanism explaining why underweight is associated with lower aspired ages for having a first child in this context may be a social one: (early) marriage often results in a social status transition, which leads to a possible decline in newlyweds' access to more or higher-quality food. Conceiving a first child often increases a young woman's social position in the household, consequently leading to better (access to) nutritious food [32]. Early marriage and childbearing may, however, compromise girls' health and have nutritional risks—including, for instance, the cessation of linear growth or competition between the (unborn) child and nutrient requirements [4]. If a girl's family formation aspirations are predictive of actual practice, our finding stresses the importance of preventing both thinness and keeping girls in school, for empowering girls to raise their aspirations in terms of marrying age.

Findings from our study advance the very limited published research on the link between malnutrition or poor diets and adolescent girls' aspirations in a low-income context. Although micronutrient deficiencies (e.g., iron, iodine, zinc deficiencies or anemia) have been extensively associated with predominantly cognitive outcomes, studies on outcomes in the noncognitive or socio-emotional domain, and particularly aspirations of adolescents, are scant [6,27]. Some evidence on nutritional indicators, in relation to aspirations, that comes from high-income contexts cannot be generalized to low-income contexts like South Asia. In our study, we attempted to move beyond the most frequently studied domain of educational aspirations by also including girls' family formation aspirations. Furthermore, our data set allowed us to start exploring potential changes in nutritional and dietary diversity indicators over the period of two years in relation to aspirations and after controlling for other important non-nutritional predictors of aspirations. Using fixed-effects regression models, we controlled for individual-level and time-invariant heterogeneity [24].

### *Methodological limitations and recommendations for future research*

We recognize several methodological limitations. First, for our analyses related to family formation aspirations, our total analytical sample sizes became relatively small because of the proportion of girls with uncertain aspirations in areas of marriage and fertility. This can have caused low statistical power, affecting our models' ability to estimate effects and potentially biasing coefficients. As uncertain aspirations are highly interesting but rarely studied, we recommend future research to include these aspirations in research on the connections

between aspirations and nutrition. Second, although the sample does span all of Nepal's development regions and agro-ecological zones, the sample cannot be considered nationally representative. Third, response bias may have arisen from asking girls the same questions in each wave, which in itself could have led to higher awareness regarding aspirations. However, we controlled for a range of factors that might affect aspirations albeit recognizing that it is probably never possible to control for all unobserved factors. Moreover, fixed-effects models cannot control for all predictors. We are therefore careful about claims regarding causality. For the fixed-effects models, sample sizes reduced because of dropped cases for which there was no change in the dependent variables (aspirations) or in nutritional predictors. For instance, although childhood HAZ has been shown to predict adolescents' educational aspirations [10], zero changes in HAZ over time left us unable to test whether catch-up growth or a recovery from stunting during adolescence affected girls' aspirations. Nonetheless, our cross-sectional models indicate that increases in HAZ were positively associated with educational aspirations. Considering that stunting, or linear growth faltering, an indicator of growing up in a deficient environment [33], often has its origins in (early) childhood, but consequences last throughout adolescence, this is an important area for further research. Likewise, we were not able to estimate models for occupational aspirations, as minimal changes resulted in poor model fit. Future research would thus benefit from including more than two periods, time lags, or larger time gaps between periods. A final point of discussion relates to the use of dietary diversity indicators for adolescents. Although DDS-W is validated for women of reproductive age, adolescent girls' nutritional needs are higher, and research has yet to confirm if this indicator and which food groups accurately reflect adolescent girls' macronutrient and micronutrient adequacy.

#### Implications for policy and practice

Despite the limitations, our findings have important implications for policies or programs that aim to foster adolescent girls' aspirations and trajectories into adulthood and consequently those of future generations. This study's findings imply that nutritional status and diets may be importantly related to adolescent girls' aspirations in Nepal and thus that improving adolescent diets and investing in adolescent nutrition may nourish aspirations. Investments in anemia and thinness prevention and control could be particularly vital to raising adolescent girls' educational and fertility aspirations, respectively. Policies and programs that invest in nutrition and healthy diets for girls would be even more important at later pubertal stages, when the effects on aspirations could be stronger.

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#### Supplementary Data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.jadohealth.2021.10.029>.

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