Original Article

Pre-earthquake national patterns of preschool child undernutrition and household food insecurity in Nepal in 2013 and 2014

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Background and Objectives: Preschool undernutrition remains a burden in Nepal. This paper reports results of surveys in 2013 and 2014, examining patterns of child nutritional status across the country, associations with household food insecurity and antecedent comparative national data for subsequent evaluations of nutritional status following the earthquake in Nepal in 2015. **Methods and Study Design:** A multi-stage sample was drawn comprising 21 sites in 75 districts of the country, representing the mountains, hills and Terai zones, providing proportionate to zonal samples of 4286 and 4947 households and 5401 and 5474 preschool children in each year, respectively. Children 6 to 59 months of age were measured for weight and height, expressed as standardized z-scores for height-for-age (HAZ), weight-for-height (WHZ), and stunting and wasting (<-2 z for each). The household food insecurity access scale (HFIAS) was used to measure food security. **Results:** Between 2013 and 2014, HAZ decreased from a mean (SD) of -1.46 (1.39) to -1.54 (1.33) z-scores, while the prevalence of stunting increased from 35.5% to 37.4% (p<0.05 for both), evident in the mountains and Terai but not hills. In both years, wasting was highest (~22%) in the Terai versus mountains or hills (~8%). More households were classified food secure in 2014 (73%) than 2013 (59%), evident in all zones. **Conclusions:** Two midyear surveys in Nepal revealed a stable nutritional situation among preschool children, reflecting a pause in the long-term decline in stunting noted in previous years. The same period saw a slight reduction in wasting and improved household food security.

Key Words: malnutrition, household food insecurity, national survey, nutrition surveillance, Nepal

INTRODUCTION

Childhood undernutrition leads to stunting, contributes to mortality and morbidity and appears to confer long-term consequences on cognition and behavior, economic productivity, and risks of adult onset diseases.[1-5] Despite a steady, global decrease in the prevalence of stunting and wasting malnutrition, and amidst growing evidence of a nutritional transition,[6] South Asia continues to be home to the world's greatest burden of undernutrition.[1] Within the region, Nepal consistently reports some of the highest prevalence estimates of these conditions, notwithstanding the substantial reductions in stunting noted in Demographic Health Surveys (DHS), from 50.5% in 2001 to 41% in 2011.[7] In the most recent DHS, preschool child rates of wasting and underweight were 11% and 29%, respectively.[8] Amidst a renewed commitment to reduce childhood malnutrition further and more quickly as part of the Sustainable Development Goals, there is interest in tracking child nutrition in Nepal more frequently, nationally and across the country's ecologically diverse zones of the Himalayan mountains, hills and the Indo-Gangetic plains (Terai), where ~7%, 43% and 50% of the country's population live, respectively.[9] Previous studies have noted higher or comparable stunting rates in the mountains

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as in the Terai with lower rates in the hills[10,11] and have identified numerous risk factors for stunting including low maternal education and height, small perceived birth size, longer duration of breastfeeding, low dietary diversity, high birth order, and lower caste and socioeconomic status.[11-13] Relationships between stunting and indicators of food insecurity have been inconsistent, however, with some studies suggesting children from more food insecure households have a greater risk of stunting[14,15] and others finding no association.[16-18] One study has attributed a recent decline in childhood stunting in Nepal to increases in asset ownership, education, healthcare, sanitation and maternal height.[7]

The Feed the Future Nutrition Innovation Lab for Nutrition (FtF NIL), a research activity supported by United States Agency for International Development in collaboration with the Government of Nepal, has conducted a series of multi-year panel surveys in the same sampled sites and in proportion to the distribution of populations in the mountains, hills and Terai. The surveys are designed to estimate the mid-year prevalence of malnutrition in preschool children and mothers and explore associations between agricultural practices, household socioeconomic and food security status, services and extension program coverage and maternal and preschool child diet and nutritional status. This paper reports on nutritional status of preschool children, as measured from May through August in 2013 and 2014, in relation to ecological zone, and household and individual characteristics framed by food security status. Motivated by the DHS finding of a marked reduction in childhood stunting from 2006 to 2011, the present report offers an opportunity to examine continuity in this trend and identify patterns of short-term change or stability of status in the same season and communities in two consecutive years. Importantly, these two, consecutive, mid-year surveys also provide the last, nationally representative estimates of preschool child nutritional and household food security status prior to a major earthquake that devastated certain areas of Nepal, one year later, in late April 2015.[19] As such, these data also represent novel "baseline" (pre-quake) profiles of nutritional conditions against which future mid-year assessments of change and resilience can be evaluated in the country.

METHODS

Data for this study was generated during two nationally representative surveys conducted in the same sampled sites across mountains, hills and Terai (plains) of Nepal from May through July in 2013 and 2014. A sampling frame was constructed by listing all 75 districts from west to east stratified by zone and, within each district, all Village Development Communities (designated Committees in Nepal, or VDCs) and municipalities comprising 543, 2,034 and 1,394 primary sampling units, ordered alphabetically across the mountains, hills and Terai, respectively. In the 1st of two stages, following a random start within each zone sampling interval, every 7th VDC was systematically sampled to provide a total of 7 in each zone, or 21 VDCs in 21 districts throughout the country. In a 2nd stage, 3 of 9 wards (smallest administrative unit) were randomly sampled from each VDC to provide a total of 63 wards (21 per zone) for the survey. In this way, sampled wards reflected zonal ward size distributions, enabling the final sample in each zone to be proportionate to that of each zone nationally.

Ethical approval for the study was provided by the Nepal Health Research Council under the Ministry of Health and Population, Government of Nepal (Reg. no 16/2013) and the Institutional Review Boards at the Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA (IRB No 00004937).

Data collection

Prior to each year's survey, enumerators, supervisors and quality control staff, employed through a national non-governmental organization (New ERA, Kathmandu), underwent intensive one-month training that included communications methods, informed consent procedures, survey instrument use, assessment procedures, familiarization with manuals, and standardization prior to deployment. Survey procedures remained the same for both surveys. Eligibility for the study was limited to households with children under the age of five years of age and/or households with a woman who was married within the past two years. These criteria were independently used during every annual survey visit. Households included in 2013 were maintained in the 2014 sample provided (1) they contained at least one child less than 72 months of age (2) the household remained in the sample study wards and had not moved out of the study area. Field staff visited eligible households in the 21 study sites and conducted interviews to collect data on household characteristics including size, indicators of socioeconomic status including asset ownership, recalled agriculture and animal production, income and expenditure, program participation, food security, food purchases in the past month, dietary intake in the past week and nutritional status of children and their mothers or other caretakers. Anthropometric measurements were taken using standard calibrated equipment. Infant/child weight was measured to the nearest 100 g on a digital scale (Seca Scales, Columbia, MD). Supine length for infants 0-23 months, and standing height for children 24-59 months was measured to 0.1 cm in triplicate using a wooden height/length board (Weigh and Measure LLC, Olney, MD, USA). All length/height measures were recorded, and the median was used for analysis.

Indicator Derivation and Data Analysis

For this report, World Health Organization (WHO) growth standards were used to compute z-scores of height-for-age (HAZ), weight-for-height (WHZ) and weight-for-age (WAZ) for children <60 months of age.[20-22] Cut-off points defined by the WHO were used to classify malnutrition: children with HAZ, WHZ and WAZ <-2 and <-3 z-scores were classified as moderately or worse and severely 'stunted,' 'wasted' and 'underweight,' respectively. Prevalence of WHZ >1 was estimated to reflect provisional risk of children being overweight. Individuals with z-scores falling outside of a fixed exclusion range (-6 >HAZ >6, -5> WHZ >5 and -6> WAZ >5) were excluded from analysis.

Household food insecurity was assessed by the House-

hold Food Access Scale (HFIAS), a tool that employs nine main questions reflecting three domains of food (anxiety over the household food supply, insufficient quality, and insufficient food intake) over the 30 days prior to the survey, enabling households to be categorized during the same season each year as mildly, moderately or severely food insecure or food secure based on recommended analytical approaches.[23] Household socioeconomic status was measured by the possession of household's durable assets and housing characteristics. Principal components analysis of the entire survey sample was used to generate a wealth index separately for each year following a previously described method,[23] which was divided into quintiles for analyses. The prevalence of stunting and wasting was compared between years using generalized linear models (Poisson and/or Binomial) with robust standard errors to adjust for clustering by wards, and adjusting for agro-ecological region. These models were also used for comparisons of child nutritional status between years within each agro-ecological stratum. Statistical analyses were performed using STATA version 13 (StataCorp, College Station, TX).

RESULTS

Of the 4379 and 5,096 eligible households identified through the screening process in 2013 and 2014, we obtained completed interviews from 4,286 and 4,947 households respectively (Figure 1). A relatively small proportion of eligible households in 2013 (2.1%) and 2014 (2.9%) were excluded due to refusal, unavailability, or interview non-completion. Child interviews were administered to 5,401 and 5,474 children <5 years for each year respectively. In 2013 and 2014, we obtained interviews with 4,509 and 5,202 mothers/female caretakers from these households. Of the original households participating in the 2013 survey, 3,725 households (86.9% of the sample) were re-interviewed and included in the 2014 round.

Table 1 describes sampled household socioeconomic

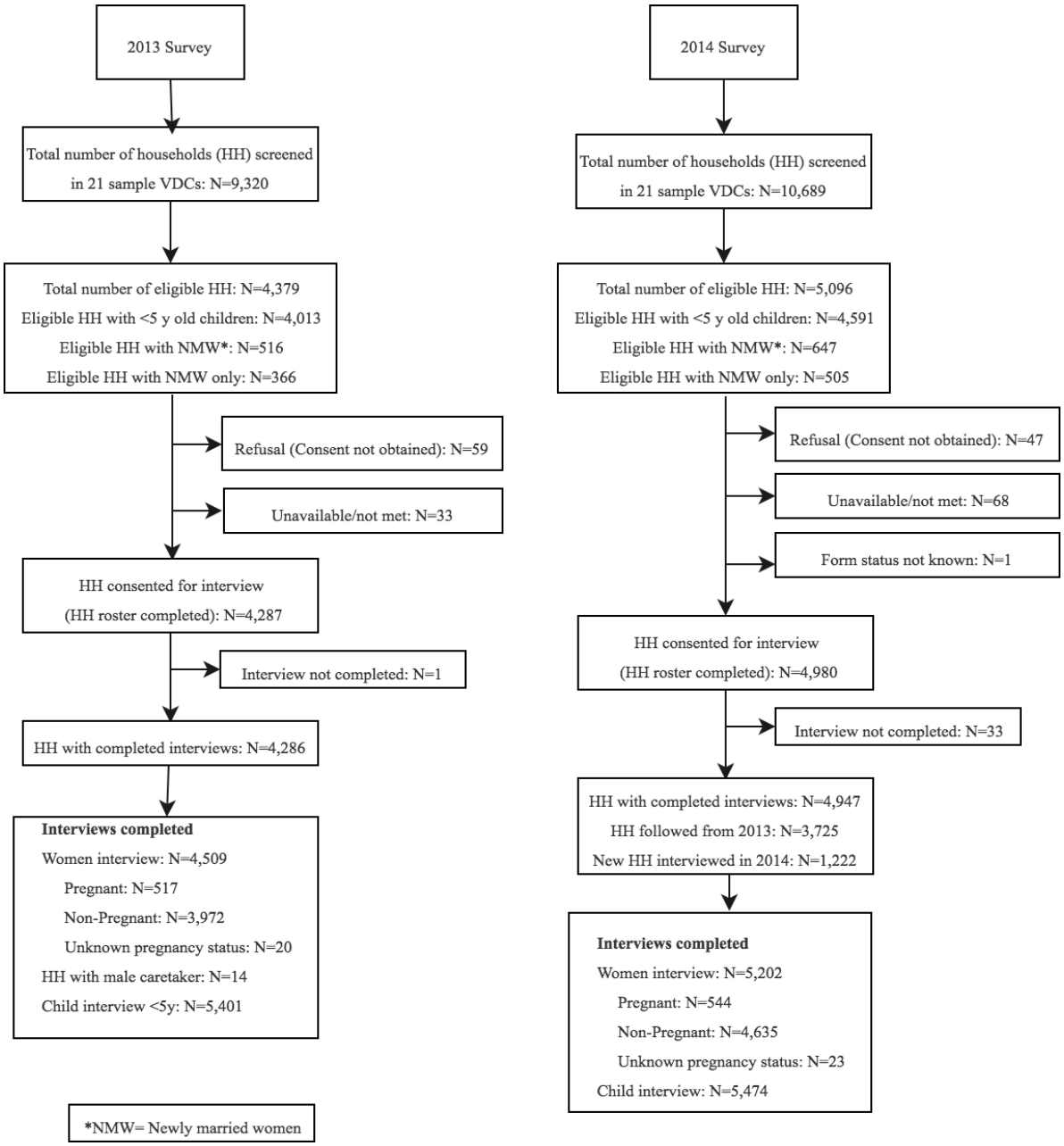

Figure 1. Consort Diagram of the Survey Participants in Panel 1 (2013) and Panel 2 (2014).

Table 1. Characteristics of surveyed households with children <60 months of age in the mountains, hills and Terai in 2013 and 2014

Household characteristics	Total		Mountains		Hills		Terai	
	2013	2014	2013	2014	2013	2014	2013	2014
Head of household, N	3862	3976	724	665	1011	1073	2127	2238
Age (yr), mean (SD)	39.8 (14.1)	40.1 (14.5)	35.7 (12.3)	35.8 (12.8)	39.7 (15.3)	39.5 (15.4)	41.2 (13.8)	41.7 (14.2)
Schooling (Yr), N	3,862	3931	724	656	1011	1060	2127	2215
0, n (%)	1789 (46.3)	1802 (45.8)	211 (29.1)	188 (28.7)	454 (44.9)	435 (41)	1124 (52.8)	1179 (53.2)
1 to 5, n (%)	730 (18.9)	747 (19)	126 (17.4)	105 (16)	204 (20.2)	221 (20.8)	400 (18.8)	421 (19)
6 to 10, n (%)	958 (24.8)	981 (25)	194 (26.8)	182 (27.7)	268 (26.5)	298 (28.1)	496 (23.3)	501 (22.6)
>10, n (%)	385 (10)	401 (10.2)	193 (26.7)	181 (27.6)	85 (8.4)	106 (10)	107 (5)	114 (5.1)
Mother, N	4070	4197	730	667	1045	1112	2295	2418
Age (vr), mean (SD)	27 (6.7)	26.8 (6.4)	27.4 (7.1)	26.9 (6.4)	27.5 (6.9)	27.5 (6.9)	26.7 (6.4)	26.5 (6.2)
Schooling (Yr), N	4070	4194	730	665	1046	1112	2294	2417
0, n (%)	2210 (54.3)	2109 (50.3)	359 (49.2)	292 (43.9)	428 (40.9)	395 (35.5)	1423 (62)	1422 (58.8)
1 to 5, n (%)	519 (12.8)	581 (13.9)	105 (14.4)	101 (15.2)	151 (14.4)	196 (17.6)	263 (11.5)	284 (11.8)
6 to 10, n (%)	924 (22.7)	1009 (24.1)	113 (15.5)	119 (17.9)	352 (33.7)	359 (32.3)	459 (20)	531 (22)
>10, n (%)	417 (10.2)	495 (11.8)	153 (21)	153 (23)	115 (11)	162 (14.6)	149 (6.5)	180 (7.4)
Assets owned/available, N	3862	3976	724	665	1011	1073	2127	2238
Radio, n (%)	923 (23.9)	869 (21.9)	289 (39.9)	238 (35.8)	297 (29.4)	311 (29)	337 (15.8)	320 (14.3)
Television, n (%)	1654 (42.8)	1871 (47.1)	299 (41.3)	292 (43.9)	380 (37.6)	474 (44.2)	975 (45.8)	1105 (49.4)
Mobile, n (%)	3376 (87.4)	3614 (90.9)	616 (85.1)	601 (90.4)	901 (89.1)	981 (91.4)	1859 (87.4)	2032 (90.8)
Electricity, n (%)	3167 (82)	3429 (86.2)	699 (96.6)	647 (97.3)	742 (73.4)	882 (82.2)	1726 (81.2)	1900 (84.9)
Source of drinking water, N	3861	3976	724	665	1011	1073	2126	2238
Tube well or borehole, n (%)	2132 (55.2)	2262 (56.9)	0 (0)	0 (0)	24 (2.4)	33 (3.1)	2108 (99.2)	2229 (99.6)
Piped water, n (%)	1425 (36.9)	1432 (36)	662 (91.4)	630 (94.7)	754 (74.6)	802 (74.7)	9 (0.4)	0 (0)
Others (including stone tap), n (%)	304 (7.9)	282 (7.1)	62 (8.6)	35 (5.3)	233 (23.1)	238 (22.2)	9 (0.4)	9 (0.4)
Wealth index, mean (SD)	-0.04(2.3)	0(2.3)	-0.3 (1.6)	-0.5 (1.5)	0.3 (2.9)	0.6 (2.7)	-0.1 (2.2)	-0.2 (2.3)
Wealth quintile, N	3858	3976	721	665	1011	1073	2126	2238
1st quintile, n (%)	797 (20.7)	814 (20.5)	85 (11.8)	88 (13.2)	296 (29.3)	199 (18.5)	416 (19.6)	527 (23.5)
2nd quintile, n (%)	783 (20.3)	802 (20.2)	154 (21.4)	155 (23.3)	149 (14.7)	162 (15.1)	480 (22.6)	485 (21.7)
3rd quintile, n (%)	774 (20.1)	797 (20)	217 (30.1)	205 (30.8)	144 (14.2)	248 (23.1)	413 (19.4)	344 (15.4)
4th quintile, n (%)	746 (19.3)	785 (19.7)	202 (28)	194 (29.2)	107 (10.6)	78 (7.3)	437 (20.6)	513 (22.9)
5th quintile, n (%)	758 (19.7)	778 (19.6)	63 (8.7)	23 (3.5)	315 (31.2)	386 (36)	380 (17.9)	369 16.5)
Household food insecurity, N	3861	3976	724	665	1010	1073	2127	2238
None, n (%)	2293 (59.4)	2916 (73.3)	366 (50.6)	423 (63.6)	577 (57.1)	763 (71.1)	1350 (63.5)	1730 (77.3)
Mild, n (%)	713 (18.5)	577 (14.5)	134 (18.5)	116 (17.4)	201 (19.9)	173 (16.1)	378 (17.8)	288 (12.9)
Moderate, n (%)	614 (15.9)	365 (9.2)	152 (21)	97 (14.6)	194 (19.2)	107 (10)	268 (12.6)	161 (7.2)
Severe, n (%)	241 (6.2)	118 (3)	72 (9.9)	29 (4.4)	38 (3.8)	30 (2.8)	131 (6.2)	59 (2.6)

characteristics, nationally and across the three different eco-cultural strata within the country. With respect to adult education, 45-48% of all heads of household and mothers had never attended school. In the mountains, fewer heads of household (30%) than mothers of children (43%) never attended school. In the hills the ratio was reversed (40% vs 33%) and in the Terai percentages for both groups were higher and comparable (53% and 56%, respectively). Zonal differences were also evident in advanced education with 21-27%, 8-15% and 5-7% of either group of adults having >10 years of schooling. Household radio ownership remained the same both years in the mountains (~38%), hills (30%) and Terai (16%) while television and mobile phone ownership rose by ~3-6% during the year, to ~47% and 91%, respectively, across the country. Nearly all homes in the mountains and ~84% in the hills and Terai reported electricity in their homes. Virtually all households surveyed both years reported their sources of water to be improved: tubewells or boreholes in the Terai (~99%), and piped, stone-tapped or similar water sources in the mountains (91-95%) and hills (~97%). Based on a wealth index constructed each year from national distributions of 25 assessed variables, in 2014 wealth increased in the hills but remained unchanged in the mountains and Terai, relative to the country as a whole. Across the national sample, based on the HFIAS questionnaire,[21] 13% more households were classified as food secure in 2014 (73%) than 2013 (59%), evident in each zone. In both years, more households were classified as food secure in the Terai than other zones.

Mean (SD) HAZ of children decreased progressively from mid-infancy onward, similarly by sex nationally and within each zone (Table 2). From 2013 to 2014, HAZ decreased overall from -1.46 (1.39) to -1.54 (1.33) z-scores (p<0.01), evident for both sexes and at each age beyond mid-infancy. The shift led to a ~2% increase in the national prevalence of stunting (<-2 HAZ), from 35.5% (95% CI: 34.2 to 36.8%) to 37.4% (95% CI: 36.1 to 38.7%) (p<0.05, Table 2). Although the wealth index was positively and negatively associated in a dose-response manner with HAZ (p<0.01) and prevalence of stunting (p<0.05), respectively, the loss in HAZ during the year was most noticeable in the 2nd and 3rd fifths of the index, nationally (Table 2) and in each zone. Height for age and the extent of stunting worsened by ~0.1 HAZ and 2-3%, respectively, in both the mountains (p=0.27) and Terai (p=0.04), but remained unchanged in the hills (Supplemental tables 1A-1C). Despite improved household food security, paradoxically HAZ worsened and the prevalence of stunting increased in each stratum of the HFIAS-based index (Table 2), a pattern that was most striking in the Terai (Supplemental Table 1C). A decrement in HAZ and increase in the prevalence of stunting from 2013 to 2014 was seen at virtually every age and all levels of food security (Supplemental tables 2A-2B).

Weight for height distributions were indistinguishable in 2013 and 2014, although nationally a slight decrease in the prevalence of wasting (<-2 WHZ) was noted, from 17.6% (95% CI: 16.6 to 18.7%) in 2013 to 16.3% in 2014 (95% CI: 15.3 to 17.3%) (p<0.05). This increment that was observed at each age beyond early infancy, by sex and across the wealth index (except the 2nd 20% of the distribution). There was no discernable pattern explaining the improved weight for height in terms of household food security status (Table 2), either nationally or by ecological zone (Supplemental Tables 1A-1C).

Weight-for-age, reflecting combined effects of HAZ and WHZ, was comparable both years, revealed by a mean (SD) of ~-1.56 (1.14) WAZ, and ~34.5% of children being <-2, ~9.5% being <-3, and ~2% being >1 WAZ in both years (Table 3).

Comparison of the present findings with previous DHS surveys revealed a continued decline in the prevalence of moderate and severe stunting (<-2 HAZ) from 2001 to 2013, followed by a slight rise in 2014. In contrast, prevalence rates of wasting in both of the present surveys were ≥50% higher (17.6% and 16.3%) than in the three earlier DHS surveys (9.6%, 12.6% and 10.9% in 2001, 2006 and 2011, respectively), due to a larger percentage of moderately wasted children (≥-3 WHZ but <-2 WHZ), leading to higher rates of underweight in the current survey years (Figure 2).

DISCUSSION

Findings from these two, consecutive national surveys provide novel insights into the stability and short-term dynamics of preschool child malnutrition, food insecurity and poverty in Nepal. From mid-2013 to mid-2014, the prevalence of childhood stunting increased 2%, from 35.5% to 37.5%, wasting decreased 1.4%, from 17.7% to 16.3%, and risk of overweight (>1 z-score in WHZ) remained <3%, leaving the prevalence of underweight at ~34.5% both years. In one way, these findings can be interpreted to reflect a generally stable year-to-year nutritional condition that, for stunting, is comparable to prevalences that have been observed in other preschool child populations of South Asia, including Bangladesh (36%), India (39%) and Bhutan (34%),[30] and more broadly throughout the region (36%).[1] Similarly, the prevalence of wasting is slightly higher than the south-central Asian regional average of 14.8% but within its 95% confidence range (11.1 to 19.4%).[1] On the other hand, the small national shifts in prevalence of stunting and wasting that were detected represent plausible changes in the period of a year[17] and, as they were unlikely to have arisen by chance, were examined more closely.

Socioeconomic indicators reflected a complex dynamic that may have affected child nutrition during the year. For example, education levels of women, access to modern communications (television and mobile phone) and a food security index all showed increments, which directly or indirectly could have had some effect on weight for height of children. During the year, hill sites exhibited the greatest gains in wealth across all quintiles of the wealth index and, in parallel, showed no deterioration in height-for-age, consistent with known protective associations of socioeconomic status against stunting.[24]

Household food security, assessed both years by the Household Food Access Scale,[21] revealed a marked increase in the percentage of food secure households from mid-2013 (59%) to mid-2014 (73%), a shift that occurred across all strata of the scale and agro-ecological zones. Yet, despite this apparent improvement in food access,

Table 2. Height-for-age and weight-for-height z-scores of children <5 years of age in 2013 and 2014

Characteristic	Height-for-age z-score						Weight-for-height z-score					
	N		Mean (SD)		n (%) <-2 z		N		Mean (SD)		n (%) <-2 z	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Total	5307	5409	-1.46 (1.39)	-1.54 (1.33)**	1884 (35.5)	2024 (37.4)*	5302	5402	-1.03 (1.07)	-1.01 (1.03)	936 (17.7)*	880 (16.3)*
Age in months												
0-5.9	454	412	-0.16 (1.41)	-0.03 (1.36)	46 (10.1)	30 (7.3)	451	407	-0.56 (1.39)	-0.70 (1.22)	68 (15.1)	56 (13.8)
6-11.9	556	641	-0.85 (1.32)	-0.96 (1.18)	104 (18.7)	104 (16.2)	554	641	-1.19 (1.19)	-1.16 (1.18)	134 (24.2)	164 (25.6)
12-23.9	1052	1062	-1.56 (1.31)	-1.63 (1.24)	385 (36.6)	422 (39.7)	1055	1062	-1.29 (1.07)	-1.18 (1.04)	276 (26.2)	219 (20.6)
24-59.9	3245	3294	-1.71 (1.30)	-1.81 (1.21)	1349 (41.6)	1468 (44.6)	3242	3292	-0.98 (0.96)	-0.96 (0.96)	458 (14.1)	441 (13.4)
Sex												
Male	2798	2865	-1.43 (1.42)	-1.55 (1.34)	989 (35.4)	1085 (37.9)	2797	2859	-1.03 (1.09)	-1.03 (1.05)	507 (18.1)	486 (17.0)
Female	2509	2544	-1.49 (1.37)	-1.53 (1.32)	895 (35.7)	939 (36.9)	2505	2543	-1.03 (1.04)	-0.99 (1.01)	429 (17.1)	394 (15.5)
Wealth index												
1st fifth	1137	1191	-1.87 (1.40)	-1.90 (1.38)	552 (48.6)	600 (50.4)	1136	1190	-1.26 (1.06)	-1.21 (1.05)	272 (23.9)	255 (21.4)
2nd fifth	1104	1117	-1.46 (1.41)	-1.68 (1.33)	400 (36.2)	482 (43.2)	1103	1116	-1.10 (1.02)	-1.16 (0.98)	193 (17.5)	206 (18.5)
3rd fifth	1082	1100	-1.49 (1.39)	-1.64 (1.26)	396 (36.6)	432 (39.3)	1080	1098	-0.96 (1.07)	-0.91 (1.03)	177 (16.4)	155 (14.1)
4th fifth	1003	1036	-1.39 (1.31)	-1.37 (1.21)	326 (32.5)	328 (31.7)	1003	1036	-0.97 (1.09)	-1.00 (1.02)	176 (17.6)	166 (16.0)
5th fifth	976	964	-1.01 (1.30)	-0.99 (1.25)	209 (21.4)	181 (18.8)	975	961	-0.82 (1.06)	-0.72 (1.02)	117 (12.0)	98 (10.2)
Household food insecurity												
None	3064	3929	-1.34 (1.39)	-1.44 (1.30)	983 (32.1)	1336 (34)	3061	3928	-0.99 (1.07)	-0.98 (1.03)	525 (17.2)	606 (15.4)
Mild	992	794	-1.56 (1.36)	-1.78 (1.36)	373 (37.6)	355 (44.7)	988	790	-1.04 (1.04)	-1.11 (1.01)	163 (16.5)	149 (18.9)
Moderate	892	510	-1.70 (1.33)	-1.86 (1.39)	384 (43.1)	250 (49.0)	893	509	-1.13 (1.08)	-1.09 (1.07)	185 (20.7)	97 (19.1)
Severe	357	175	-1.56 (1.58)	-1.85 (1.36)	142 (39.8)	82 (46.9)	358	174	-1.09 (1.06)	-1.11 (0.96)	62 (17.3)	28 (16.1)

*p<0.05, **p<0.01 GLM models to test for difference in prevalence between years, adjusting for agro-ecological region and ward clustering.

Table 3. Weight-for-age z-scores and extremes of distribution of weight-for-height (<-3 to >1 WHZ) of children <5 years of age in 2013 and 2014 surveys

	Weight-for-age z-score						Weight-for-height z-score					
	N		Mean (SD)		n (%) <-2 z		N		n (%) <-3 z		n (%) >1 z	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Total	5348	5447	-1.55 (1.15)	-1.57 (1.12)	1840 (34.4)	1884 (34.6)	5302	5402	189 (3.6)	141 (2.6)**	153 (2.9)	147 (2.7)
Age in months												
0-5.9	455	413	-0.54 (1.35)	-0.54 (1.32)	56 (12.3)	40 (9.7)	451	407	21 (4.7)	15 (3.7)	52 (11.5)	26 (6.4)
6-11.9	557	643	-1.42 (1.23)	-1.44 (1.21)	166 (29.8)	219 (34.1)	554	641	38 (6.9)	30 (4.7)	18 (3.3)	28 (4.4)
12-23.9	1062	1071	-1.70 (1.14)	-1.66 (1.12)	420 (39.6)	413 (38.6)	1055	1062	60 (5.7)	39 (3.7)	22 (2.1)	24 (2.3)
24-59.9	3274	3320	-1.66 (1.04)	-1.7 (0.99)	1198 (36.6)	1212 (36.5)	3242	3292	70 (2.2)	57 (1.7)	61 (1.9)	69 (2.1)
Sex												
Male	2819	2884	-1.52 (1.16)	-1.57 (1.11)	962 (34.1)	1002 (34.7)	2797	2859	101 (3.6)	82 (2.9)	84 (3)	81 (2.8)
Female	2529	2563	-1.58 (1.15)	-1.58 (1.13)	878 (34.7)	882 (34.4)	2505	2543	88 (3.5)	59 (2.3)	69 (2.8)	66 (2.6)
Wealth index												
1st fifth	1143	1197	-1.95 (1.16)	-1.92 (1.11)	573 (50.1)	545 (45.5)	1136	1190	59 (5.2)	55 (4.6)	22 (1.9)	20 (1.7)
2nd fifth	1111	1127	-1.61 (1.11)	-1.76 (1.04)	374 (33.7)	464 (41.2)	1103	1116	42 (3.8)	26 (2.3)	22 (2)	18 (1.6)
3rd fifth	1088	1106	-1.52 (1.11)	-1.57 (1.07)	363 (33.4)	369 (33.4)	1080	1098	32 (3)	28 (2.6)	33 (3.1)	28 (2.6)
4th fifth	1011	1046	-1.46 (1.12)	-1.46 (1.06)	330 (32.6)	310 (29.6)	1003	1036	32 (3.2)	21 (2)	32 (3.2)	30 (2.9)
5th fifth	990	970	-1.13 (1.10)	-1.05 (1.11)	200 (20.2)	195 (20.1)	975	961	24 (2.5)	11 (1.1)	43 (4.4)	51 (5.3)
Household food insecurity												
None	3095	3958	-1.45 (1.16)	-1.49 (1.10)	970 (31.3)	1254 (31.7)	3061	3928	98 (3.2)	94 (2.4)	100 (3.3)	114 (2.9)
Mild	997	799	-1.61 (1.12)	-1.79 (1.11)	354 (35.5)	330 (41.3)	988	790	40 (4.1)	30 (3.8)	19 (1.9)	14 (1.8)
Moderate	896	514	-1.77 (1.11)	-1.82 (1.19)	374 (41.7)	217 (42.2)	893	509	39 (4.4)	15 (3)	24 (2.7)	16 (3.1)
Severe	358	175	-1.67 (1.22)	-1.83 (1.07)	140 (39.1)	82 (46.9)	358	174	12 (3.4)	2 (1.2)	10 (2.8)	3 (1.7)

*p<0.05, **p<0.01 GLM models to test for difference in prevalence between years, adjusting for agro-ecological region and ward clustering.

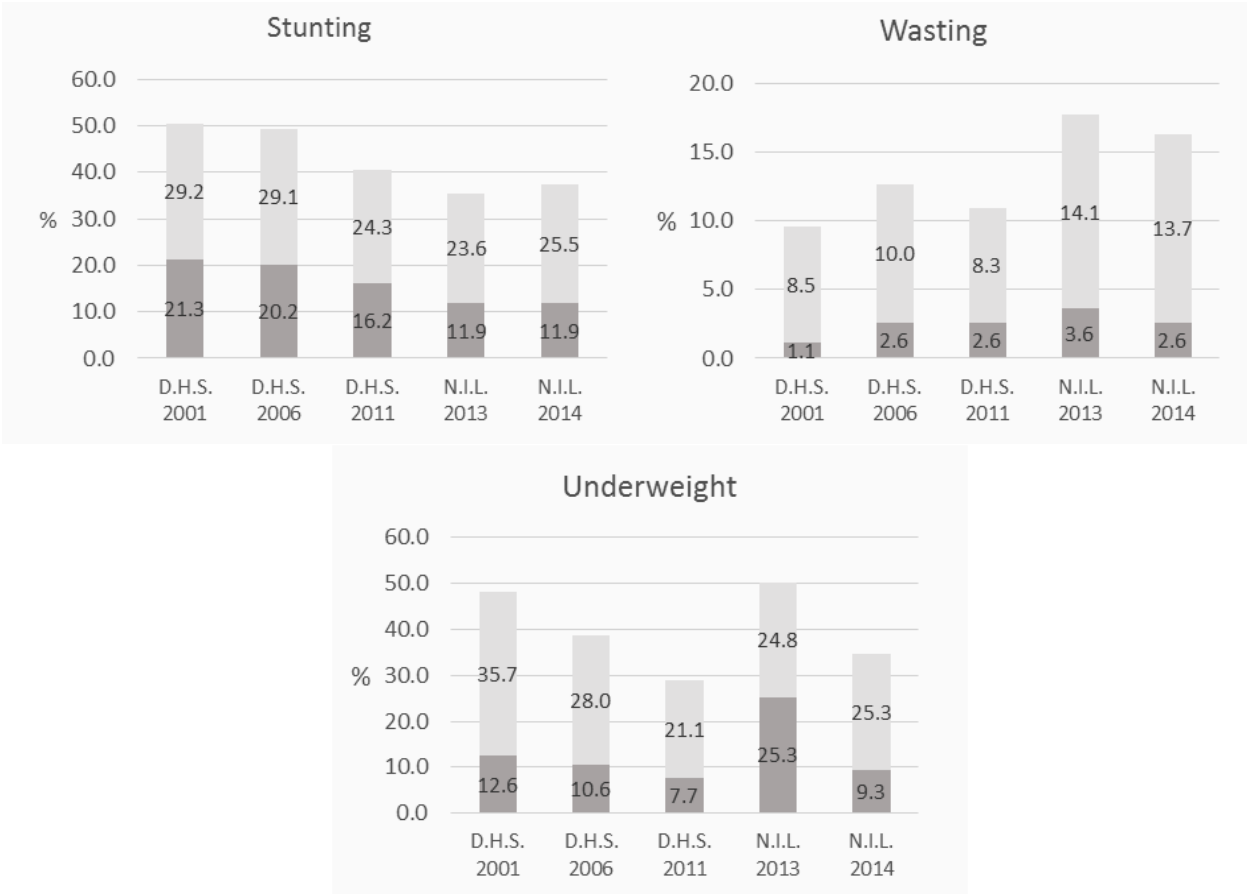

Figure 2. Trends in Stunting, Wasting and Underweight of Preschool Children in Nepal from Nepal Demographic Health Surveys (NDHS) in 2001, 2006 and 2011 and Nutrition Innovation Lab (NIL) Surveys of 2013 and 2014[†]. [†]Stunting, wasting and underweight are defined by z-score cut-offs of -2 HAZ, WHZ and WAZ (light plus dark segments of bars), with severe status (dark segment) representing status <-3 HAZ, WHZ and WAZ, respectively.

there was only a minimal shift in preschool child WHZ and HAZ declined, leading to small increases in the prevalence of stunting at nearly all ages and within each stratum of household food insecurity. Several reasons may underlie this seeming paradox: (a) improved child growth may lag an increase in food access and intake, and thus require a longer time than the concurrent year to respond; (b) a larger food basket in the home may not be sufficiently nutritious to stimulate (catch-up) growth when fed to children; (c) improved food security may not improve a preschooler's diet to stimulate additional linear growth; and (d) an acceleration in linear growth at ages examined may not be a plausible response under sustained conditions of poverty, food insecurity (even if improved), infectious and other environmental stresses in Nepal. Recent population cohort studies have not consistently demonstrated increments in HAZ with improved household food security after adjustments for potential confounders.[25] Agricultural, socioeconomic, and dietary patterns that may explain the improved food security in the country are being investigated.

The Terai had the largest percentage of food secure households, and is the zone most advanced in agricultural practices and productive with respect to food in Nepal.[26] Yet, both prevalence rates of 23.3% and 21.6% in child wasting were consistent with previous estimates of childhood wasting in this agro-ecological zone,[27,28] exceeding estimates in other zones by two-fold. Also, the lower 95% limits for both rates exceeded the 15% threshold (calculated from Table 2) for global acute malnutrition, a cut-off applied to wasting malnutrition by the WHO to define a humanitarian emergency.[28] The discordance of widespread wasting malnutrition amidst advanced agricultural productivity implicates complex causal pathways between local agricultural practices and childhood nutrition, as has been reported elsewhere.[29] The findings specifically suggest a need to closely examine factors that mediate access to food by vulnerable groups, including the mixes of accessed foods contributing to a food secure situation, cultural taboos, poor adult education, and gender inequities that may affect intra-household child feeding and poor hygiene and sanitation also associated with childhood malnutrition.[30-36]

The 2013 and 2014 surveys offer opportunity to compare findings on preschool child malnutrition with previous demographic health surveys in Nepal (NDHS). Between 2001 and 2011, three NDHS reported a steady decline in the prevalence of stunting, from 51.5% in 2001 to 40.5% in 2011.[18] Our findings suggest that stunting continued to decline at a rate of 2.3% per year to a prevalence of 35.5% in 2013, consistent with efforts to reach a target of 40% fewer stunted children in the country by 2025.[25] However, a 2% increase in prevalence, noted above, to 37.5% in 2014 appears to reflect either a pause in the declining trend or inter-year variation in the prevalence of stunting not captured between less frequent, mid-decadal

surveys. Reasons for the halt in decline are currently not understood.

The national prevalence of wasting was markedly higher in 2013 (17.7%) than reported by the NDHS in 2011 (10.9%). However, in 2013 rates of wasting were nearly the same as 2011 in the hill (10.7% vs 10.9%) and mountainous (8.3% vs 10.7%) zones, leaving a difference, of 23.3% vs 11.2%, in the Terai to explain variation in the national prevalence.[8] Among reasons to rule out is the difference in season of assessment, as seasonality is known to influence nutritional status in South Asia.[35-37] The 2011 NDHS was conducted in the months of February through May, a relatively food secure time of year, versus June to August for both the present surveys. While this could lead to a difference, given children in the mountains and hills were measured the same months, where weight-for-height was comparable to the NDHS, this is an unlikely reason for the prevalence being higher in the Terai the 2013 survey. As sampling variability or imbalances in sample size units across diverse regions could distort estimates, as a sensitivity analysis, we weighted reported prevalence rates of wasting and stunting from the 2011 NDHS by our population samples in each ecological zone and found only slight differences in national estimates of stunting (10.9% original vs. 11.0% reweighted) and wasting (40.5% original vs 41.2% reweighted). These considerations support an interpretation that differences in prevalence across the DHS and FtF NIL surveys are unbiased and real.

We found little evidence of the double burden of malnutrition among Nepalese preschoolers with fewer than 3% of children having a weight for height beyond 1 z-score. However, given some evidence that the nutrition transition is underway among adults in Nepal, particularly in urban areas, it is important that public health surveys continue to track this indicator.[37]

Strengths of this study included a representative sampling design, large sample size and low refusal rates (~1% each year) strengthening confidence in generating unbiased estimates of child status and household conditions in two years across three agro-ecological zones of Nepal. Both surveys visited the same sampled communities and households during the same mid-year months of the year, thus controlling for sampling variation and seasonal influences on nutritional status between surveys. In the 2nd year, we recruited households with newly eligible children and censured for this analysis children >60 months of age, thereby preserving the cross-sectional age structure and comparability. Field staff were trained and standardized in the same measurement and interviewing procedures both years.

A unique facet of these two same sample, consecutive-year surveys, and the stability of preschool child nutritional status conveyed in the findings, is that they provide a reliable pre-earthquake comparator for post-2015 quake national assessments of stability, change and resilience in nutritional, food security and socioeconomic conditions in Nepal. To this end, a 3rd national survey of this same sample across the mountains, hills and Terai was conducted and is currently undergoing analysis (Manohar S et al., personal communication, 2017).

In conclusion, two, annual national surveys among preschool Nepalese children have revealed (a) a prevalence of stunting of 37%, commensurate with much of South-Central Asia and a pause in a previous 13-year decline in this condition, and (b) a slow decline in the prevalence of wasting, to 16%, which however remains especially high in the Terai. During the same interval, using a standardized index, nationally perceived food security rose by 13% that was, nonetheless, unrelated to early childhood nutritional status.

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AUTHOR DISCLOSURES

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Supplemental table 1A. Height and weight-for-height z-scores of preschool children in mountains in the 2013 and 2014 surveys

	Height-for-age z-score						Weight-for-height z-score					
	N		Mean (SD)		n (%) <-2 z		N		Mean (SD)		n (%) <-2 z	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Total	932	826	-1.50 (1.39)	-1.59 (1.37)	346 (37.1)	323 (39.1)	929	824	-0.60 (1.06)	-0.65 (1.00)	77 (8.3)	60 (7.3)
Age in months												
0-5.9	83	49	-0.42 (1.39)	0.27 (1.54)	10 (12.1)	4 (8.2)	81	48	0.20 (1.47)	-0.25 (1.42)	6 (7.4)	3 (6.3)
6-11.9	77	85	-0.76 (1.36)	-0.97 (1.14)	14 (18.2)	13 (15.3)	76	85	-1.00 (1.28)	-0.89 (1.13)	16 (21.1)	11 (12.9)
12-23.9	157	165	-1.80 (1.38)	-1.79 (1.11)	75 (47.8)	72 (43.6)	157	165	-0.81 (1.03)	-0.75 (0.99)	21 (13.4)	16 (9.7)
24-59.9	615	527	-1.66 (1.30)	-1.80 (1.30)	247 (40.2)	234 (44.4)	615	526	-0.60 (0.91)	-0.61 (0.92)	34 (5.5)	30 (5.7)
Sex												
Male	489	431	-1.50 (1.43)	-1.58 (1.39)	191 (39.1)	172 (39.9)	489	430	-0.55 (1.08)	-0.64 (1.04)	39 (8.0)	30 (7.0)
Female	443	395	-1.50 (1.34)	-1.60 (1.35)	155 (35.0)	151 (38.2)	440	394	-0.66 (1.03)	-0.66 (0.95)	38 (8.6)	30 (7.6)
Wealth index												
1st fifth	115	120	-1.76 (1.46)	-1.62 (1.61)	56 (48.7)	54 (45.0)	114	120	-0.89 (1.13)	-0.83 (1.08)	20 (17.5)	16 (13.3)
2nd fifth	216	196	-1.45 (1.39)	-1.68 (1.59)	79 (36.6)	90 (45.9)	215	196	-0.71 (0.94)	-0.79 (1.02)	17 (7.9)	17 (8.7)
3rd fifth	288	260	-1.50 (1.37)	-1.72 (1.21)	106 (36.8)	102 (39.2)	288	258	-0.57 (1.04)	-0.63 (0.91)	22 (7.6)	19 (7.4)
4th fifth	241	222	-1.45 (1.38)	-1.38 (1.23)	79 (32.8)	73 (32.9)	240	222	-0.42 (1.12)	-0.48 (1.02)	14 (5.8)	8 (3.6)
5th fifth	69	27	-1.42 (1.37)	-1.21 (0.79)	25 (36.2)	3 (11.1)	69	27	-0.54 (0.99)	-0.38 (0.82)	3 (4.4)	0 (0.0)
Household food insecurity												
None	433	508	-1.44 (1.39)	-1.53 (1.30)	149 (34.4)	183 (36.0)	432	508	-0.46 (1.05)	-0.54 (0.95)	27 (6.3)	21 (4.1)
Mild	176	147	-1.51 (1.25)	-1.79 (1.38)	64 (36.4)	71 (48.3)	175	146	-0.63 (1.00)	-0.81 (1.02)	12 (6.9)	17 (11.6)
Moderate	213	131	-1.56 (1.35)	-1.65 (1.47)	84 (39.4)	53 (40.5)	213	131	-0.77 (1.04)	-0.80 (1.16)	23 (10.8)	18 (13.7)
Severe	110	39	-1.58 (1.63)	-1.35 (1.81)	49 (44.6)	15 (38.5)	109	38	-0.80 (1.16)	-0.88 (0.85)	15 (13.8)	4 (10.5)

$^{*}p<0.05$, $^{**}p<0.01$ GLM models to test for difference in prevalence between years, adjusting for agro-ecological region and ward clustering.

Supplement table 1B. Height-for-age and weight-for-height z-scores of preschool children in hills in the 2013 and 2014 surveys

	Height-for-age z-score						Weight-for-height z-score					
	N		Mean (SD)		n (%) <-2 z		N		Mean (SD)		n (%) <-2 z	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Total	1264	1307	-1.45 (1.36)	-1.47 (1.37)	457 (36.2)	482 (36.9)	1266	1308	-0.74 (1.05)	-0.63 (1.02)*	136 (10.7)	115 (8.8)
Age in months												
0-5.9	114	113	-0.10 (1.38)	0.04 (1.25)	12 (10.5)	6 (5.3)	114	113	-0.29 (1.26)	-0.31 (1.05)	10 (8.8)	6 (5.3)
6-11.9	142	137	-0.71 (1.20)	-0.73 (1.29)	19 (13.4)	22 (16.1)	142	137	-0.83 (1.13)	-0.59 (1.25)	19 (13.4)	18 (13.1)
12-23.9	262	263	-1.46 (1.33)	-1.37 (1.36)	91 (34.7)	92 (35.0)	264	263	-0.95 (1.06)	-0.77 (0.99)	36 (13.6)	29 (11.0)
24-59.9	746	794	-1.80 (1.21)	-1.85 (1.19)	335 (44.9)	362 (45.6)	746	795	-0.72 (0.97)	-0.64 (0.97)	71 (9.5)	62 (7.8)
Sex												
Male	671	696	-1.44 (1.36)	-1.50 (1.37)	239 (35.6)	261 (37.5)	672	695	-0.79 (1.08)	-0.65 (1.00)	83 (12.4)	60 (8.6)
Female	593	611	-1.47 (1.37)	-1.44 (1.38)	218 (36.8)	221 (36.2)	594	613	-0.68 (1.01)	-0.6 1(1.05)	53 (8.9)	55 (9.0)
Wealth index												
1st fifth	403	263	-1.97 (1.20)	-2.06 (1.20)	204 (50.6)	144 (54.8)	404	263	-1.15 (1.03)	-0.85 (1.05)	77 (19.1)	36 (13.7)
2nd fifth	199	212	-1.61 (1.27)	-1.85 (1.27)	76 (38.2)	108 (50.9)	199	212	-0.69 (0.99)	-0.88 (0.95)	16 (8.0)	25 (11.8)
3rd fifth	176	317	-1.50 (1.35)	-1.75 (1.25)	73 (41.5)	140 (44.2)	176	317	-0.63 (0.98)	-0.70 (1.02)	13 (7.4)	27 (8.5)
4th fifth	129	92	-1.32 (1.42)	-1.27 (1.35)	47 (36.4)	28 (30.4)	129	92	-0.65 (1.08)	-0.58 (1.05)	13 (10.1)	9 (9.8)
5th fifth	357	423	-0.79 (1.30)	-0.75 (1.30)	57 (16.0)	62 (14.7)	358	424	-0.39 (0.98)	-0.33 (0.96)	17 (4.8)	18 (4.3)
Household food insecurity												
None	683	904	-1.17 (1.39)	-1.32 (1.37)	198 (29.0)	292 (32.3)	684	905	-0.60 (1.05)	-0.55 (1.01)	66 (9.7)	66 (7.3)
Mild	262	223	-1.54 (1.22)	-1.72 (1.30)	96 (36.6)	94 (42.2)	261	222	-0.71 (0.98)	-0.82 (0.99)	22 (8.4)	25 (11.3)
Moderate	270	138	-2.01 (1.18)	-1.94 (1.41)	141 (52.2)	74 (53.6)	270	139	-1.07 (1.04)	-0.82 (1.09)	41 (15.2)	21 (15.1)
Severe	47	42	-1.75 (1.43)	-1.94 (1.05)	20 (42.6)	22 (52.4)	49	42	-1.05 (1.03)	-0.66 (1.02)	6 (12.2)	3 (7.1)

*p<0.05, **p<0.01 GLM models to test for difference in prevalence between years, adjusting for agro-ecological region and ward clustering.

Supplement table 1C. Height-for-age and weight-for-height z-scores of preschool children in the Terai in the 2013 and 2014 surveys

	Height-for-age z-score						Weight-for-height z-score					
	N		Mean (SD)		n (%) <-2 z		N		Mean (SD)		n (%) <-2 z	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Total	3111	3276	-1.45 (1.41)	-1.56 (1.30)	1081 (34.8)	1219 (37.2)*	3107	3270	-1.28 (1.01)	-1.25 (0.97)	723 (23.3)	705 (21.6)
Age in months												
0-5.9	257	250	-0.10 (1.43)	-0.12 (1.36)	24 (9.3)	20 (8.0)	256	246	-0.93 (1.29)	-0.97 (1.18)	52 (20.3)	47 (19.1)
6-11.9	337	419	-0.93 (1.36)	-1.03 (1.15)	71 (21.1)	69 (16.5)	336	419	-1.39 (1.14)	-1.40 (1.09)	99 (29.5)	135 (32.2)
12-23.9	633	634	-1.54 (1.28)	-1.70 (1.20)	219 (34.6)	258 (40.7)	634	634	-1.56 (1.00)	-1.47 (0.97)	219 (34.5)	174 (27.4)
24-59.9	1884	1973	-1.70 (1.33)	-1.80 (1.20)	767 (40.7)	872 (44.2)	1881	1971	-1.21 (0.91)	-1.19 (0.9)	353 (18.8)	349 (17.7)
Sex												
Male	1638	1738	-1.41 (1.44)	-1.56 (1.31)	559 (34.1)	652 (37.5)	1636	1734	-1.28 (1.03)	-1.28 (1.00)	385 (23.5)	396 (22.8)
Female	1473	1538	-1.49 (1.38)	-1.55 (1.29)	522 (35.4)	567 (36.9)	1471	1536	-1.28 (0.98)	-1.22 (0.93)	338 (23.0)	309 (20.1)
Wealth index												
1st fifth	619	808	-1.82 (1.51)	-1.90 (1.39)	292 (47.2)	402 (49.8)	618	807	-1.40 (1.04)	-1.38 (0.99)	175 (28.3)	203 (25.2)
2nd fifth	689	709	-1.43 (1.46)	-1.63 (1.27)	245 (35.6)	284 (40.1)	689	708	-1.34 (0.98)	-1.34 (0.92)	160 (23.2)	164 (23.2)
3rd fifth	618	523	-1.48 (1.42)	-1.55 (1.29)	217 (35.1)	190 (36.3)	616	523	-1.24 (1.02)	-1.18 (1.02)	142 (23.1)	109 (20.8)
4th fifth	633	722	-1.39 (1.26)	-1.38 (1.19)	200 (31.6)	227 (31.4)	634	722	-1.25 (0.98)	-1.21 (0.94)	149 (23.5)	149 (20.6)
5th fifth	550	514	-1.09 (1.28)	-1.17 (1.19)	127 (23.1)	116 (22.6)	548	510	-1.14 (1.01)	-1.07 (0.96)	97 (17.7)	80 (15.7)
Household food insecurity												
None	1948	2517	-1.38 (1.38)	-1.46 (1.27)	636 (32.7)	861 (34.2)	1945	2515	-1.25 (1.00)	-1.21 (0.98)	432 (22.2)	519 (20.6)
Mild	554	424	-1.58 (1.45)	-1.81 (1.39)	213 (38.5)	190 (44.8)	552	422	-1.33 (0.99)	-1.37 (0.94)	129 (23.4)	107 (25.4)
Moderate	409	241	-1.57 (1.37)	-1.92 (1.31)	159 (38.9)	123 (51.0)	410	239	-1.36 (1.09)	-1.41 (0.91)	121 (29.5)	58 (24.3)
Severe	200	94	-1.51 (1.59)	-2.03 (1.23)	73 (36.5)	45 (47.9)	200	94	-1.26 (0.99)	-1.40 (0.88)	41 (20.5)	21 (22.3)

*p<0.05, **p<0.01 GLM models to test for difference in prevalence between years, adjusting for agro-ecological region and ward clustering.

Supplemental table 2. Mean height-for-age z-scores of preschool children by household food security in the 2013 and 2014 surveys

	Height-for-age z-score								
	Household food secure			Mild household food insecurity			Moderate/ Severe household food insecurity		
Age in months	N	Mean (SD)	% <-2 HAZ	N	Mean (SD)	% <-2 HAZ	N	Mean (SD)	% <-2 HAZ
2013 Survey									
0-5.9	275	0.00 (1.38)	8.4	91	-0.29 (1.40)	9.9	88	-0.54 (1.45)	15.9
6-11.9	328	-0.70 (1.36)	16.2	108	-0.94 (1.13)	16.7	120	-1.19 (1.32)	27.5
12-23.9	638	-1.40 (1.31)	31.7	174	-1.67 (1.21)	40.8	239	-1.87 (1.31)	46.4
24-35.9	587	-1.54 (1.31)	36.1	203	-1.89 (1.29)	50.7	235	-1.92 (1.31)	49.4
36-47.9	645	-1.79 (1.29)	43.3	199	-1.87 (1.20)	44.7	289	-1.76 (1.43)	46.0
48-59	591	-1.57 (1.18)	36.2	217	-1.70 (1.35)	38.2	278	-1.72 (1.36)	42.8
2014 Survey									
0-5.9	313	0.05 (1.31)	5.8	48	-0.18 (1.40)	10.4	51	-0.42 (1.55)	13.7
6-11.9	474	-0.87 (1.13)	14.1	89	-1.07 (1.44)	18.0	78	-1.39 (1.09)	26.9
12-23.9	780	-1.49 (1.25)	34.7	155	-1.88 (1.07)	48.4	127	-2.22 (1.16)	59.8
24-35.9	783	-1.81 (1.21)	44.8	171	-2.16 (1.28)	56.1	125	-2.24 (1.44)	65.6
36-47.9	765	-1.71 (1.14)	40.1	154	-2.06 (1.29)	51.9	143	-2.02 (1.27)	55.2
48-59	814	-1.67 (1.14)	39.6	177	-1.87 (1.26)	46.9	161	-1.82 (1.31)	41.6