

Prevalence and predictors of undernutrition among children under two years in Narmada District, Gujarat State, Western India: a community-based cross-sectional study

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ABSTRACT

Background: Globally, addressing undernutrition has been recognised as a development priority. In India, undernutrition continues to be the topmost risk factor for morbidity and associated mortality. The Government of India, through the National Nutrition Strategy, aims to reduce child mortality by preventing and reducing undernutrition among children. The aim of this study was to estimate prevalence and predictors of undernutrition among children under two years in Narmada district of Gujarat state, India.

Methods: A community-based cross-sectional survey was completed between July and August 2019. A probability sample of 400 children under two years of age were surveyed. A structured tool was used to collect data on exposures- socioeconomic conditions, dietary diversity, maternal care, infant feeding practices, household food insecurity, and child morbidity. The WHO child growth standards (2006) were used to measure the outcome (wasting, stunting and underweight). We used multivariate logistic regression analysis to identify the predictors of undernutrition.

Results: The prevalence of wasting, stunting, and underweight were 32.2% (95% CI: 27.0-37.9), 34.5% (95% CI: 29.5-39.8), and 39.7% (95% CI: 33.9-45.8), respectively. Household income >10000 Indian Rupees-INR (OR: 0.61, 95% CI: 0.4, 0.90), maternal stature ≥ 145 cm (OR: 0.43, 95% CI: 0.21, 0.86) and child age 0-6 months (OR: 1.61, 95% CI: 1.00-2.56) were significantly associated with wasting. Household income (OR: 0.50, 95% CI: 0.26, 0.97), livestock ownership (OR 2.36: 95% CI: 1.25, 4.44), maternal body mass index ≥ 18.5 (OR: 0.63, 95% CI: 0.42, 0.95), and child age 7-23 months (OR: 5.89, 95% CI: 3.03, 11.45) were significantly associated with stunting. Maternal stature ≥ 145 cm (OR: 0.46, 95% CI: 0.23, 0.95) was significantly associated with underweight.

Conclusions: In Narmada, the prevalence of undernutrition among children under two years is high. To improve the situation, targeting the nutritional status of adolescent girls and mothers, strengthening already existing programs, and education on hygiene should be considered.

Keywords: Malnutrition, wasting, stunting, underweight, prevalence, children

INTRODUCTION

Maternal and child undernutrition are among the world's most serious economic, health and human development challenges. Annually, undernutrition contributes to an estimated 3.1 million (45%) child deaths worldwide [1]. Maternal and child undernutrition have adverse consequences for pregnancy outcomes, child morbidity and mortality, children's mental and motor development, and chronic diseases in later life [2]. The impact of undernutrition is not only limited to the health-related outcomes only, but can also affect educational performance, economic productivity, and human wellbeing [2].

Addressing the burden of undernutrition has been recognised as a global priority- in 2012 the World Health Organization (WHO) specified six global nutrition targets to be achieved by 2025 and in 2016 the United Nations (UN) Decade of Action on Nutrition (2016-25) was launched [3, 4]. Yet, globally in 2018, an estimated 149 million (22%) children under five years were stunted and 49 million (7.3%) were wasted [5]. Although there has been some progress in achieving the global nutrition targets, many high-burden countries are off-course [6].

As one of the high burden countries, 38.4% young children in India are stunted, 35.7% underweight and 21.0% wasted children [7]. Undernutrition continues to be the topmost risk factor for morbidity and associated mortality in India- accounting for more than two-third of under-five deaths [8]. In line with the Global Development Goals, the Government of India, in 2017, developed a National Nutrition Strategy (NNS) with the vision of a "malnutrition free India" by 2022 [9]. This strategy aims to reduce child mortality by preventing and reducing undernutrition among children by three percentage points per annum. Subsequently, in 2018, the National Nutrition Mission, also known as the Prime Minister's Overarching Scheme for Holistic Nourishment (POSHAN *Abhiyan*) was launched [10]. It is considered to be a "People's Movement" and mainly focuses on strengthening the already existing programs through convergence, community engagement, partnerships and use of information technology.

To accelerate nutrition actions under POSHAN *Abhiyan*, high burden districts across the states have been identified by the NNS. Ever since these districts were identified, many developmental partners and non-governmental organisations have collaborated with the Department of Health and Family Welfare (DHFV) and the Department of Women and Child Development (DWCD) to support nutrition actions. A large nutrition project is one of such initiatives being implemented in Narmada district- one of the high burden districts in Gujarat state.

This paper presents the results of baseline survey for a large nutrition project that aims to prevent wasting among children under two years of age in Narmada district, Gujarat state, India.

METHODS

Study setting

The study was conducted in Narmada district, Gujarat State, western India. The district has a total population of 590,297 (90% rural and 82% tribal). Overall, there are 558 inhabited villages and 5 towns. The district has a literacy rate of 72% and the economy is basically dependent on agricultural activities (85%).

Study design and sample size

A cross-sectional design was used to collect data during July and August 2019. This survey was designed to provide baseline information on nutritional status of children under two years in Narmada district. Sample size was determined using a comparison of repeated survey approach to assess the impact of an intervention over time. The calculation was based on the following assumptions: 36% prevalence of wasting, 5% level of significance, 80% power, 5% non-response rate and a design effect of 2. We estimated that a total sample size of 400 was sufficient to detect a minimum change of 15 percentage points in proportion undernourished.

Sampling technique and procedures

A two-stage cluster sampling technique was used to first select the villages (clusters) and then the households. In the first stage, 40 villages were selected using a probability proportional to size technique. In the second stage, a list of households with infants under two years old was collected from respective village heads. Ten households per village were randomly selected for interview. We used computer generated random numbers.

Data collection procedure and quality assurance

A structured questionnaire was used to collect data through face-to-face interviews from mothers of sample children. The information collected included demographic and socioeconomic characteristics; dietary diversity; infant and young child feeding practices (IYCF); maternal antenatal-delivery-postnatal care; household food insecurity (HFI); morbidity; and anthropometric measurements. The questionnaire was developed in English and then translated into the local language (Gujarati) by the research team. This was field tested and revised accordingly.

Dietary diversity was measured for both the mothers and children using FAO/FANTA and WHO guidelines, respectively [11, 12]. We used a 24-hour dietary recall method to calculate the number of food groups consumed. For mothers, the foods were classified into ten groups: i) grains, white roots, and tubers, and plantains; ii) pulses (beans, peas, and lentils); iii) nuts and seeds; iv) dairy; v) meat, poultry, and fish; vi) eggs; vii) dark green leafy vegetables; viii) other vitamin A-rich fruits and vegetables; ix) other vegetables; and x) other fruits. For children the foods were classified into seven groups: i) grains, roots and tubers; ii) legumes and nuts; iii) dairy products (milk, yogurt, cheese); iv) flesh foods (meat, fish, poultry and liver/organ meats); v) eggs; vi) vitamin-A rich fruits and vegetables; and vii) other fruits and vegetables. Women's diet were considered diverse if they consumed food from at least five food groups out of ten, while children's diet was considered diverse if they consumed food from at least four food groups out of seven. Based on this, a minimum dietary diversity (MDD) score was calculated for each.

IYCF indicators were constructed as per WHO guidelines [12]. We measured four indicators: early initiation of breastfeeding, duration of exclusive breastfeeding, timely introduction of complementary foods, and minimum dietary diversity.

HFI was measured using Food and Nutrition Technical Assistant (FANTA) project guidelines [13]. We asked nine questions to mothers related to the household's experience of food insecurity in the last month preceding the survey. These questions had three major domains of HFI: i) anxiety and uncertainty about access (1-question), ii) insufficient quality (3-questions), and iii) insufficient quantity (5-questions). Each item starts with an occurrence question that identifies if the condition has been experienced in the household. An affirmative answer is then followed by a frequency-of-occurrence question to determine if the condition

happened rarely (once or twice), sometimes (3-10 times), or often (>10 times) during the last month. The responses were coded as- 1=rarely, 2= sometimes, or 3= often. From these questions, we formed the Household Food Insecurity Access Prevalence (HFIAP) indicator. Using this, we categorised household security into two levels of HFI: food secure and food insecure.

Anthropometry included weight (mother-child) and height/length (mother-child) measurements using protocols described in FANTA guidelines [14]. Weight for the mother was measured to the nearest 0.1 kg (Seca 874 electronic scale) and for children to the nearest 0.1 kg (Seca 364 infant electronic scale). Similarly, height (Seca 213 stadiometer) and length (Seca 210 measuring mat) for mother and child were measured to the nearest 1 cm.

The data collection team included two research assistants (RA) and eight field investigators (FI). The RAs had formal training in public health nutrition, including a focus on anthropometry. The FIs were graduates from local areas with some fieldwork experience. The questionnaire was administered by FIs, while anthropometry was performed by the RAs. Two separate training sessions were conducted, one for RAs and other for FIs. RAs were trained at the Indian Institute of Public Health Gandhinagar (IIPHG) by the principal investigator. This included the conceptual framework for malnutrition, survey design, sampling techniques and data collection. The FIs were trained at Rajpipla village in Narmada (a field station) by the RAs. Their training mainly focused on the survey questionnaire.

There were two levels of supervision, ensuring the quality of the data collection: RAs (field supervisors) and a remote supervisor (principal investigator). The field supervisors were responsible for checking anthropometric measurements and observing interviewers throughout the survey. Collected data were entered into Excel the same day by RAs and were shared with the principal investigator for checking. Any inaccuracies found were resolved the next day.

Data processing and analysis

The raw data were cleaned, coded and analysed (adjusted for cluster sampling) using STATA version 15. Three anthropometric indicators were generated: weight-for-height/length (WHZ), height/length-for-age (HAZ), and weight-for-age (WAZ), using the WHO child growth standards [15-17]. These were used to generate outcome indicators--wasted, stunted or underweight as WHZ, HAZ, and WAZ scores <-2 standard deviations (SD), respectively.

Firstly, we used the univariate analysis to examine the distributions of variables. This was used to understand the study population characteristics. The results are presented as percentages for categorical variables and means with SD for continuous variables. Secondly, we calculated the prevalence of anthropometric deficits (wasted, stunted, and underweight) among children. Thirdly, we performed a bivariate analysis to assess associations between exposure (household, maternal and child related) and outcome variables (wasting, stunting and underweight). Those found to be significantly associated ($p < 0.05$) were then included in the multivariate analysis. Finally, logistic regression (multivariate) analysis was performed to investigate the net effect of each exposure on wasting, stunting and underweight, adjusting for all other variables in the model. These results are presented as adjusted odds ratios (OR) with 95% confidence intervals.

Ethics approval and consent to participate

Ethics approval and clearance was obtained from the Institution Ethics Committee of Indian Institute of Public Health Gandhinagar (IIPHG). Study participants (mothers) were informed

about the research objectives, methods, and techniques in detail and written informed consent was taken.

RESULTS

Characteristics of study population

A total of 400 mother-child pairs participated in the study. Characteristics of household, mothers and their children are presented in Table 1. A majority of the households were Hindus and belonged to the scheduled-castes/scheduled-tribes (SC/ST) category. Regarding socio-economic conditions, 61.5% had a monthly family income \leq 10,000 INR (140 USD) and nearly three-quarters (73.5%) owned livestock. Two-thirds of households were living in *kutchha* (made of mud or thatch) and the rest in *pucca* (made of stones, asbestos sheets, burnt bricks, cement bricks or concrete) houses and around half did not have their own toilets. Most (86.2%) of the households reported being food secure.

Table 1: Socio-economic and demographic characteristics of children under 2 years and their mothers, in Narmada district, Gujarat state, Western India

Characteristics	Category	Frequency	Percent (%)
Religion	Hindu	377	94.2
	Muslim	16	4.0
	Christian	7	1.8
Caste	General	9	2.2
	SC/ST	376	94.0
	OBC	15	3.8
Monthly family income (₹)	\leq 10000	246	61.5
	$>$ 10000	154	38.5
Family type	Joint	105	26.2
	Nuclear	295	73.8
House type	Kutchha	265	66.2
	Pucca	135	33.8
Land ownership	Yes	332	83.0
	No	68	17.0
Livestock ownership	None	106	26.5
	\geq 1	294	73.5
Toilet availability	Yes	203	50.8
	No	197	49.2
Household food insecurity	Secure	345	86.2
	Insecure	55	13.8

Notes: SC- scheduled-castes; ST- scheduled-tribes; OBC- other so-called backward castes

Regarding maternal characteristics, the mean age was 24.8 ± 3.75 years and most (83.5%) were literate (Table 2). A small proportion (13.2%) reported early marriage ($<$ 18 years). Maternal antenatal, delivery and postnatal care were found to be satisfactory. The mean body mass index (BMI) was 19.4 ± 3.09 , with 44% mothers being underweight and 7.5% having short stature ($<$ 145 cm). The mean dietary diversity score for mothers was 4.3 ± 0.99 and 43.2% did not meet the minimum dietary diversity. Regarding infant and young child feeding practices, three indicators were satisfactory (exclusive breastfeeding- 97%, early initiation- 80.5%, and minimum dietary diversity- 71.4%), while the timely introduction of complementary feeding was low (55.8%). The mean age of children was 10.6 ± 6.31 months. The male-female ratio was nearly equal. 16.8% of children were reported to have had diarrhoea in last two weeks.

Table 2: Maternal characteristics and IYCF practices

Characteristics	Category	Frequency	Percent (%)
Maternal age, years (Mean±SD)		24.8±3.75	
Maternal education	Literate	334	83.5
	Illiterate	66	16.5
Age at marriage, years	<18	53	13.2
	≥ 18	347	86.8
Parity	1-3	370	92.5
	≥4	30	7.5
Maternal height, cm	<145	45	11.2
	≥145	355	88.8
Maternal BMI, kg/m ² (Mean±SD)		19.4±3.09	
Maternal nutrition status	BMI <18.5	176	44
	BMI ≥18.5	224	56
Maternal dietary diversity (Mean±SD)		4.3±0.99	
MDD-M	Yes	227	56.8
	No	173	43.2
Antenatal visits	≥ 4 times	297	74.2
	< 4 times	103	25.8
Place of delivery	Home	34	8.5
	Institution	366	91.5
Delivery type	Normal	366	91.5
	Caesarean	34	8.5
Assistance during delivery	Yes	348	87.0
	No	52	13.0
Received postnatal care	Yes	366	91.5
	No	34	8.5
Early initiation of breastfeeding	Yes	323	80.8
	No	77	19.2
Exclusive breastfeeding (0-5 months)	Yes	98	97.0
	No	3	3.0
Timely introduction of complementary feeding (6-8 months)	Yes	29	55.8
	No	23	44.2
Child dietary diversity (Mean±SD) (7-23 months)		2.5±1.39	
MDD-C	Yes	205	71.4
	No	82	28.6
Child age, months (Mean±SD)		10.6±6.31	
Child age group, months	0-6	113	28.2
	7-23	287	71.8
Child gender	Male	206	51.5
	Female	194	48.5
Diarrhoea (last two weeks)	Yes	67	16.8
	No	333	83.2

Note: MDD-M- minimum dietary diversity for mothers; MDD-C- minimum dietary diversity for child

Prevalence of undernutrition

The prevalence of wasting, stunting and underweight were 32.2% (95% CI: 27.0-37.9), 34.5% (95% CI: 29.5-39.8), and 39.7% (95% CI: 33.9-45.8), respectively (Table 3). The mean weight-for-height (WHZ), height-for-age (HAZ), and weight-for-age (WAZ) z scores were -1.37 ± 0.09 , -1.37 ± 0.10 , and -1.73 ± 0.07 , respectively.

Table 3: Prevalence of undernutrition among children under 2 years in Narmada district, Gujarat state, Western India

Indicator	Category	Percentage (95% CI)
Wasted	<-2SD	32.2 (27.0-37.9)
	<-3SD	10.5 (7.0-15.3)
Stunted	<-2SD	34.5 (29.5-39.8)
	<-3SD	14.7 (10.2-17.0)
Underweight	<-2SD	39.7 (33.9-45.8)
	<-3SD	13.2 (10.2-17.0)

Table 5 presents the results of adjusted analysis, which identified monthly family income, livestock ownership, maternal height, maternal nutritional status and child age as factors associated with undernutrition.

Monthly family income and child age were associated with both wasting and stunting (though in the latter case, in opposite directions). As shown in Table 5, having a higher income reduced the risk of malnutrition by nearly half. Among older children, the risk of stunting was higher, whereas the risk of wasting was lower.

Livestock ownership and maternal nutritional status were associated with only stunting. Relative to households with no livestock, households with one or more livestock had 2.36 (95% CI: 1.25-4.44, strong evidence) times odds of having a stunted child. Relative to mothers with BMI $< 18.5 \text{ kg/m}^2$, mothers with BMI $\geq 18.5 \text{ kg/m}^2$ had 0.63 (95% CI: 0.42-0.95, good evidence) times odds of having a stunted child.

Maternal height was associated with both wasting and underweight. Relative to mothers with short stature, mothers with height $\geq 145 \text{ cm}$ had 0.43 (95% CI: 0.21-0.86, good evidence) times the odds of having a wasted child and 0.46 (95% CI: 0.23-0.95, good evidence) times odds of having an underweight child.

Factors associated with undernutrition and strength of association

Bivariate analyses identified thirteen factors associated with undernutrition (Table 4). These factors were included in the multivariate analysis.

Table 4: Bivariate analysis showing associations of household, maternal and child characteristics with undernutrition outcomes among children under 2 years in Narmada district, Gujarat state, Western India

Variables	Wasted			Stunted			Underweight		
	No n (%)	Yes n (%)	p- value	No n (%)	Yes n (%)	p- value	No n (%)	Yes n (%)	p- value
Religion									
Hindu	253 (67.1%)	124 (32.9%)	0.214	244 (64.7%)	133 (35.3%)	0.038	226 (59.9%)	151 (40.1%)	0.001
Muslim	14 (87.5%)	2 (12.5%)		14 (87.5%)	2 (12.5%)		13 (81.2%)	3 (18.8%)	
Christian	4 (57.1%)	3 (42.9%)		4 (57.1%)	3 (42.9%)		2 (28.6%)	5 (71.4%)	
Caste									
General	8 (88.9%)	1 (11.1%)	0.103	7 (77.8%)	2 (22.2%)	0.009	7 (77.8%)	2 (22.2%)	0.005
SC/ST	250 (66.5%)	126 (33.5%)		241 (64.1%)	135 (35.9%)		220 (58.5%)	156 (41.5%)	
OBC	13 (86.7%)	2 (13.3%)		14 (93.3%)	1 (6.7%)		14 (93.3%)	1 (6.7%)	
Monthly family income (₹)									
≤10000	156 (63.4%)	90 (36.6%)	0.022	150 (61.0%)	96 (39.0%)	0.042	140 (56.9%)	106 (43.1%)	0.103
>10000	115 (74.7%)	39 (25.3%)		112 (72.7%)	42 (27.3%)		101 (65.6%)	53 (34.4%)	
House type									
Kutcha	170 (64.1%)	95 (35.9%)	0.043	173 (65.3%)	92 (34.7%)	0.914	153 (57.7%)	112 (42.3%)	0.171
Pucca	101 (74.8%)	34 (25.2%)		89 (65.9%)	46 (34.1%)		88 (65.2%)	47 (34.8%)	
Livestock ownership									
None	76 (71.7%)	30 (28.3%)	0.279	81 (76.4%)	25 (23.6%)	0.020	69 (65.1%)	37 (34.9%)	0.233
1 or >	195 (66.3%)	99 (33.67%)		181 (61.6%)	113 (38.4%)		172 (58.5%)	122 (41.5%)	
Toilet availability									
Yes	144 (70.9%)	59 (29.1%)	0.234	139 (68.5%)	64 (31.5%)	0.215	133 (65.5%)	70 (34.5%)	0.018
No	127 (64.5%)	70 (35.5%)		123 (62.4%)	74 (37.6%)		108 (54.8%)	89 (45.2%)	
Age at marriage, years									
<18	34 (64.1%)	19 (35.9%)	0.653	27 (50.9%)	26 (49.1%)	0.027	28 (52.8%)	25 (47.2%)	0.351
≥ 18	237 (68.3%)	110 (31.7%)		235 (67.7%)	112 (32.3%)		213 (61.4%)	134 (38.6%)	
Maternal height, cm									
<145	21 (46.7%)	24 (53.3%)	0.006	28 (62.2%)	17 (37.8%)	0.625	19 (42.2%)	26 (57.8%)	0.023

Variables	Wasted			Stunted			Underweight		
	No n (%)	Yes n (%)	p- value	No n (%)	Yes n (%)	p- value	No n (%)	Yes n (%)	p- value
≥145	250 (70.4%)	105 (29.6%)		234 (65.9%)	121 (34.1%)		222 (62.5%)	133 (37.5%)	
Maternal nutrition status									
BMI <18.5	114 (64.8%)	62 (35.2%)	0.329	105 (59.7%)	71 (40.3%)	0.011	99 (56.2%)	77 (43.8%)	0.143
BMI ≥18.5	157 (70.1%)	67 (29.9%)		157 (70.1%)	67 (29.9%)		142 (63.4%)	82 (36.6%)	
Place of delivery									
Home	19 (55.9%)	15 (44.1%)	0.189	20 (58.8%)	14 (41.2%)	0.349	13 (38.2%)	21 (61.8%)	0.024
Institution	252 (68.8%)	114 (31.2%)		242 (66.1%)	124 (33.9%)		228 (62.3%)	138 (37.7%)	
Child age, months									
0-6	68 (60.2%)	45 (39.8%)	0.037	98 (86.7%)	15 (13.3%)	0.000	76 (67.3%)	37 (32.7%)	0.125
7-23	203 (70.7%)	84 (29.3%)		164 (57.1%)	123 (42.9%)		165 (57.5%)	122 (42.5%)	
Child gender									
Male	131 (63.6%)	75 (36.4%)	0.047	132 (64.1%)	74 (35.9%)	0.424	119 (57.8%)	87 (42.2%)	0.329
Female	140 (72.2%)	54 (27.8%)		130 (67.0%)	64 (33.0%)		122 (62.9%)	72 (37.1%)	
Diarrhoea (last 2 weeks)									
Yes	40 (59.7%)	27 (40.3%)	0.086	39 (58.2%)	28 (41.8%)	0.167	32 (47.8%)	35 (52.2%)	0.028
No	231 (69.4%)	102 (30.6%)		223 (67.0%)	110 (33.0%)		209 (62.8%)	124 (37.2%)	

Table 5: Multivariate logistic regression analysis showing factors associated with undernutrition among children under 2 years in Narmada district, Gujarat state, Western India

Variables	Wasting		Stunting		Underweight	
	OR(95%CI)	p-value	OR(95%CI)	p-value	OR(95%CI)	p-value
Religion						
Hindu	1		1		1	1
Muslim	0.67(0.17-2.64)	0.564	0.78(0.12-4.85)	0.788	1.58(0.34-7.31)	0.547
Christian	2.3(0.42-13.53)	0.317	1.50(0.52-4.29)	0.439	3.9(1.26-12.21)	0.019
Caste						
General	1		1		1	1
SC/ST	2.04(0.25-16.44)	0.493	1.22(0.37-3.98)	0.736	2.13(0.30-14.93)	0.436
OBC	1.40(0.11-16.42)	0.782	0.17(0.12-2.55)	0.198	0.26(0.02-2.40)	0.228
Monthly family income (₹)						
≤10000	1		1		1	

Variables	Wasting		Stunting		Underweight	
	OR(95%CI)	p-value	OR(95%CI)	p-value	OR(95%CI)	p-value
>10000	0.61(0.41-0.90)	0.016	0.50(0.26-0.97)	0.043	0.71(0.45-1.12)	0.143
House type						
Kutcha	1		1		1	
Pucca	0.83(0.49-1.41)	0.493	1.71(0.97-3.01)	0.063	1.18(0.74-1.88)	0.458
Livestock ownership						
None	1		1		1	
1 or >	1.37(0.78-2.39)	0.258	2.36(1.25-4.44)	0.009	1.39(0.81-2.36)	0.219
Toilet availability						
Yes	1		1		1	
No	1.21(0.73-1.99)	0.444	1.23(0.81-1.86)	0.308	1.47(0.95-2.27)	0.076
Age at marriage, years						
<18	1		1		1	
≥ 18	1.05(0.44-2.49)	0.898	0.58(0.30-1.12)	0.106	0.87(0.40-1.87)	0.724
Maternal height, cm						
<145	1		1		1	
≥145	0.43(0.21-0.86)	0.020	0.69(0.32-1.48)	0.341	0.46(0.23-0.95)	0.038
Maternal nutrition status						
BMI <18.5	1		1		1	
BMI ≥18.5	0.88(0.53-1.45)	0.613	0.63(0.42-0.95)	0.029	0.87(0.57-1.34)	0.546
Place of delivery						
Home	1		1		1	
Institution	0.77(0.33-1.8)	0.548	0.89(0.42-1.86)	0.752	0.47(0.19-1.16)	0.101
Child age, months						
0-6	1		1		1	
7-23	0.62(0.39-1.00)	0.050	5.89(3.03-11.45)	0.000	1.62(0.91-2.86)	0.093
Child gender						
Male	1		1		1	
Female	0.70(0.46-1.06)	0.093	0.94(0.60-1.45)	0.779	0.85(0.52-1.39)	0.527
Diarrhoea (last 2 weeks)						
Yes	1		1		1	
No	0.80(0.49-1.30)	0.365	0.84(0.48-1.48)	0.556	0.62(0.36-1.07)	0.087

DISCUSSION AND CONCLUSIONS

The prevalence of wasting among children <2 years in Narmada was above the critical value of public health significance ($\geq 15\%$) [18]. Similarly, the prevalence of underweight and stunting were found to be in a very high category (30-39%). We identified monthly family income and child age as being associated with both wasting and stunting; households with a low monthly family income had higher odds of having a wasted and stunted child. Younger children had higher odds of wasting, while older children had higher stunting odds. Maternal height was associated with both wasting and underweight; mothers with short stature had higher odds of having a stunted and underweight child. Livestock ownership and low maternal nutritional status were associated with a higher odds of being stunted.

Comparing these 2019 estimates with National Family Health Survey (NFHS-4) data for this district from 2015-16, an improvement was observed in all three estimates- wasting (37.2% to 32.2%), stunting (47.9% to 34.5%) and underweight (55.3% to 39.7%) [7]. However, these NFHS-4 estimates were for children under 5 years and the present study includes only children under 2 years.

Evidence on growth faltering suggests focusing on the first 1,000 days- from conception to child's second birthday, for setting the foundation of optimum growth, neurodevelopment, and health across the lifespan [1]. Yet, many studies focus on older children. Numerous studies have assessed the prevalence and associated factors of undernutrition among children under five years in high burden countries; however, again very few have focused on younger children [19-22]. Studies from Africa have identified birth weight, child age, diarrhoea (individual level); nutrition status, education level, home delivery, (maternal level); socio-economic status, number of children, and death of other children (household level) as predictors [23, 24]. Similarly, Asia-based studies found birth weight, child's gender, diarrhoea, immunization status (individual level); height, nutritional status, education level, age at first pregnancy (maternal level); socio-economic status, food security status, and toilet availability (household level) as predictors of undernutrition among under two children [25-27]. Unlike these studies, our study did not find household food insecurity, toilet availability, number of children, maternal education level or maternal age at first pregnancy as significant predictors.

In Narmada district, to address the high levels of undernutrition among children that are associated with household livestock keeping and economic conditions, and maternal short stature and nutrition status, a comprehensive approach is needed. Evidence suggests livestock keeping has both positive and negative effects on child undernutrition [28-30]. The positive effects include improved diet quality (access to nutrient-rich animal-source foods) and nutritious food purchase (livestock-derived income), while negative effects include exposure to livestock faeces (leading to diarrhoea or environmental enteric dysfunction). The negative association found in our study suggests a need for educating these communities regarding hygiene practices, especially with respect to livestock.

Maternal stature is an indicator of intergenerational linkages between maternal and child nutrition status and is identified as a strong predictor of child undernutrition in low- and middle-income countries (LMICs) [31]. Pooled analysis from LMICs showed that for every 1cm increase in maternal height the risk of stunting was reduced by 4% and wasting by 1% [31, 32]. To break the intergenerational cycle, ensuring adequate adolescent girls' nutrition is critical. Government of India's existing programs, such as public distribution system, and supplementary nutrition have the potential to improve household economic conditions,

adolescent nutrition, and maternal nutrition status. However, the implementation and coverage of these schemes need to be explored in Narmada District.

This study provided a situational analysis of child undernutrition and information on its predictors for a large nutrition project. The key messages for intervention planning include focusing on adolescent girls, informing households about the existing programs, and education on hygiene practices.

Given the high proportion of infants 0-6 months who were exclusively breastfed, it was surprising that they suffered from more wasting than older infants. We suspect this was likely due to low birth weight, which is very common throughout India. However, we did not obtain data on birth weight.

Findings should be interpreted considering the following limitations. Firstly, as this was a cross-sectional study, one should interpret the associations between exposures and outcomes as causality only with caution. Secondly, child feeding practices could be important determinants but were not explored in this study. Thirdly, we suspect social desirability bias could have affected responses to household food insecurity questions. Despite these limitations, this study also has notable strengths. For anthropometric measurements, we used standard equipment with high precision and trained personnel. We provide district-level estimates of child undernutrition, which can be used as baseline prevalence to evaluate the impact of the POSHAN *Abhiyan* (the Government of India's strategy to strength existing nutrition interventions/programs) in Narmada district.

Acknowledgements

We would like to express our heartfelt gratitude to study participants and field investigators.

Funding

Adani Foundation (AF), a corporate social responsibility Organisation, funded this study. AF did not participate in the design of the study, data collection, analysis, interpretation, or in writing the manuscript.

Availability of data and materials

The raw data used in this study are available from the corresponding author on request.

Authors' contributions

RR was involved in all stages (conception and design, data acquisition, analysis and interpretation) and wrote the first draft. AS and RN played major role in data acquisition, AS was also involved in data analysis. DNH was involved in design and analysis. DNH also provided comments on first draft. All authors have approved the final version of this article.

Competing interests

The authors declare that they have no competing interests.

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