Received: 24 September 2022 | Revised: 16 January 2023 | Accepted: 20 January 2023

DOI: 10.1002/hsr2.1093

ORIGINAL RESEARCH

Health Science Reports Open Access WILEY

Role of seasonality variation in prevalence and trend of childhood wasting in India: An empirical analysis using National Family Health Surveys, 2005–2021

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Abstract

Background: Wasting develops over a short period and can be reversed with short-term interventions. The prevalence of wasting typically varies from season to season—becoming higher during the monsoon (June to September) season as compared to the winter (October to January) and summer (February to May) seasons every year in a cyclical fashion. However, to the best of our knowledge, using nationally representative demographic surveys to extensively study the impact of the timing of the survey on the results and trends around wasting has not been done so far.

Objectives: The goal of this study is to ascertain whether seasonality has an impact on the trend and levels of wasting between NFHS-3 (2005–2006) and NFHS-5 (2019–2021).

Methods: The analysis was based on data on 51,555, 259,627, and 232,920 children under 5 years included in NFHS-3, NFHS-4, and NFHS-5 respectively. Multivariable logistic regression analysis and the predicted probabilities approach were employed to examine the effect of the months of interview on the prevalence of wasting. The analysis was conducted for 9 states of India which had data for comparable months to compute wasting levels.

Results: We found that at the national level, wasting increased in India by one per cent from NFHS-3 to NFHS-4 but declined by 2% from NFHS-4 to NFHS-5. The results show that seasonality significantly influenced the prevalence of wasting. It was observed that compared to January, the odds of wasting were particularly higher in summer and monsoon seasons, especially in the month of August across all three rounds, indicating the influence of seasonality in the prevalence of wasting in the country.

Discussion: The prevalence of wasting in India needs to be interpreted across seasonal changes as seasonality affects many of the variables intrinsically related to child health and nutritional status.

KEYWORDS
India, month of survey, NFHS, seasonality, wasting

1 | INTRODUCTION

Wasting, or low weight-for-height, is a strong predictor of mortality among children under 5. It is usually a result of acute significant food shortage and/or disease. The WHO has declared wasting as a public health concern if its prevalence is ≥15%.[1] Over half of the world's wasted children (26.9 million) live in South Asia, with 25.5 million living in India alone.[2]

According to the latest round of the National Family Health Survey (NFHS-5, 2019–2021), the prevalence of stunting among under-5 children reduced considerably between 2005–2006 and 2019–2021, from 48% (95% confidence interval [CI] 44.2–51.8)[3] to 35.5% (95% CI 35.1–35.8).[4] During the same period, however, the prevalence of wasting remained almost the same [19.8% (95% CI 19.2–20.4) in 2005–2006 and 19.2% (95% CI 18.9–19.5) in 2019–2021].

Wasting develops over a short period and can be reversed with short-term interventions.[5] The prevalence of wasting typically varies according to season due to variations in climate, disease, and food availability.[6] There also exists a considerable interstate variation with respect to wasting as is evident from the fact that between the two time points (2005–2006 and 2019–2021), 15 out of 29 Indian states showed an increase in prevalence, while 14 states showed a decline. However, it is interesting to note that all 29 states showed a reduction in stunting levels during the same period.[3,4]

While several risk factors, including seasonal food insecurity and environmental conditions, are associated with wasting[5,7–10] the contrasts in the prevalence of wasting have perplexed the stakeholders given that India's economic growth has been decent, nutrition programs have been scaled up, and policy and legal action related to the right to food has improved during the study period. Madan et al.[11] after considering various potential methodological issues (e.g., data quality, age estimation bias), argued that collecting data during one set of months in one survey and a different set in the other survey (NFHS-3 and NFHS-5) may have introduced bias in the comparative prevalence of wasting at the national level.[11]

The peaking of wasting levels during certain periods of a year is a well-documented phenomenon.[12–14] In countries of the tropical and subtropical zones, seasonal climatic changes determine the agricultural cropping patterns. Hence, the production and availability of locally produced foodstuffs affect the levels of wasting.[11,15] Furthermore, the incidence of certain infections, including acute diarrheal diseases, often follows a seasonal pattern. In many geographical areas, diarrhea occurs in definite seasonal patterns. Thus, seasonal fluctuations in children's nutritional status have been reported from various countries in Asia, Africa, and Latin America.[16–21] Seasonal diarrhea is typically more prevalent around the end of the summer and in the early rainy season. Bacterial diarrhea is more common in temperate climates during the warm season, while viral diarrhea, particularly rotavirus-related diarrhea, is more prevalent during the dry, cooler months (National Health Portal). A prolonged sickness may cause nutritional failing, raising the chance of death as a result. Malnutrition, especially wasting, is a powerful predictor of the length of diarrhea.[22]

Many studies have highlighted that the prevalence of wasting depends upon the season—higher during the monsoon (June to September) as compared to the winter (October to January) and summer (February to May) seasons and changes every year in a cyclical fashion.[12–14,23–25] However, to the best of our knowledge, the impact of the timing of the survey on the results and trends around wasting using nationally representative demographic surveys has not been studied extensively. This paper sets out to determine if seasonality played a role in influencing the trend and levels of wasting between NFHS-3 (2005–2006) and NFHS-5 (2019–2021). In other words, we aim to understand if there was a bias of seasonality on the trends of wasting using three rounds of NFHS surveys.

2 | METHODOLOGY

The analysis was based on data on 51,555, 259,627, and 232,920 children under 5 years included in NFHS-3, NFHS-4, and NFHS-5, respectively. NFHS-4 and NFHS-5 were designed to provide district-level estimates, while NFHS-3 was designed to provide state-level estimates alone. All the rounds of NFHS data provide information on date of birth, height, weight, and date of interview (for detailed sampling).[4]

Variable description: The dependent variable in this study was the prevalence of wasting (low weight-for-height, which is <-2SD of the WHO Child Growth Standards). The effect of the season (month of interview) on the prevalence of wasting was studied using data from three rounds of NFHS surveys. Wasting levels were first computed for the NFHS-3, 4, and 5 data sets by month of interview and then compared. The predictor variables included months of interview and states.

To meaningfully interpret trends in wasting levels, we selected the 12 most populous states of India as per Census 2011 (viz. Uttar Pradesh, Maharashtra, Bihar, West Bengal, Madhya Pradesh, Rajasthan, Karnataka, Gujarat, Andhra Pradesh, Odisha, Jharkhand, and Assam), which had comparable data between the survey periods. The month-wise prevalence of wasting was estimated and compared for each of the states for each round. Data collection for NFHS-3 (2005–2006) was spread across 9 months from December 2005 until August 2006, for NFHS-4 (2015–2016) across 24 months from January 2015 until December 2016, and for the latest round—that is, NFHS-5—across 12 months from 17 June 2019 to 30 April 2021. Phase one of NFHS-5 was conducted from June 2019 to January 2020, and phase two was conducted from January 2020 to April 2021.

TABLE 1 Months of data collection and comparable months to observe wasting during NFHS-3, NFHS-4, and NFHS-5 surveys in 12 select States.

States	No. of comparable months	Round	Months of data collection											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Uttar Pradesh	4	R3	✓	✓	✓	✓								✓
		R4	✓	✓	✓	✓	✓	✓	✓	✓	✓			
		R5	✓	✓	✓	✓						✓	✓	✓
Maharashtra	0	R3	✓	✓	✓									✓
		R4				✓	✓	✓	✓	✓	✓	✓		
		R5						✓	✓	✓	✓	✓	✓	✓
Bihar	1	R3				✓	✓	✓	✓					
		R4			✓	✓	✓	✓	✓	✓	✓			
		R5							✓	✓	✓	✓	✓	✓
West Bengal	2	R3	✓	✓	✓	✓	✓							✓
		R4		✓	✓	✓	✓	✓	✓					
		R5						✓	✓	✓	✓	✓	✓	✓
Madhya Pradesh	2	R3				✓	✓	✓	✓	✓				
		R4	✓	✓	✓	✓	✓	✓	✓					
		R5	✓	✓	✓	✓	✓						✓	✓
Rajasthan	3	R3	✓	✓	✓	✓								✓
		R4	✓	✓	✓	✓	✓	✓	✓					
		R5	✓	✓	✓									✓
Karnataka	1	R3				✓	✓	✓	✓					
		R4		✓	✓	✓	✓	✓	✓					
		R5							✓	✓	✓	✓	✓	✓
Gujarat	0	R3	✓	✓	✓									✓
		R4	✓	✓	✓	✓	✓	✓						
		R5						✓	✓	✓	✓	✓	✓	✓
Andhra Pradesh	0	R3	✓	✓	✓	✓								✓
		R4					✓	✓	✓	✓				
		R5							✓	✓	✓	✓	✓	
Odisha	4	R3	✓	✓	✓	✓								✓
		R4	✓	✓	✓	✓	✓	✓	✓					
		R5	✓	✓	✓	✓							✓	✓
Jharkhand	2	R3				✓	✓	✓	✓	✓				
		R4				✓	✓	✓	✓	✓	✓	✓	✓	✓
		R5	✓	✓	✓	✓	✓					✓		✓
Assam	4	R3	✓	✓	✓	✓								✓
		R4	✓	✓	✓								✓	✓
		R5						✓	✓	✓	✓	✓	✓	✓

(Continues)

TABLE 1 (Continued)

States	No. of comparable months	Round	Months of data collection											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
INDIA	9	R3	✓	✓	✓	✓	✓	✓	✓	✓				✓
		R4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		R5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Note: R3/4/5—National Family Health Survey—Round 3/4/5.

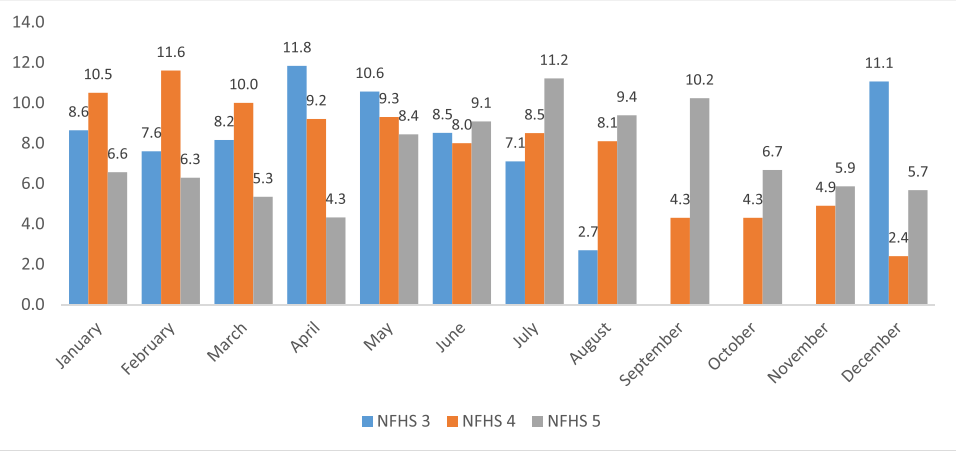

FIGURE 1 Prevalence of diarrhea in the last 2 weeks before the survey among children under age 5 years according to month of interview, NFHS-3, 4, and 5.

In NFHS-3, the highest sample of under-5 children ($N = 8526$) was covered in June 2006; in NFHS-4 ($n = 48{,}654$) in May 2015; and in NFHS-5 ($N = 39{,}529$) in the month of February 2020 and 2021. Overall, the number of under-5 children covered during NFHS-4 and NFHS-5 was over 5 times that covered under NFHS-3.

Table 1 shows the month of the interview and the number of comparable months to observe wasting levels in all three rounds of the NFHS survey in the 12 selected states. Among the selected states, only 9 were shortlisted to compare wasting levels between the three survey periods (Maharashtra, Andhra Pradesh, and Gujarat were not included). The period (3–4 months in common) during which data on wasting was collected coincided only for these 9 states. Choosing any other period could have potentially introduced bias in the interpretation of the trends in wasting levels.

Multivariable logistic regression analysis was employed to examine the effect of the month of interview on the prevalence of wasting. The regression model used in its general form was defined as:

$$\ln(\pi / 1 - \pi) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots\ldots\ldots + \beta_n X_n \ldots\ldots \quad (1)$$

where π was the probability of wasting among children.

X_is were the set of predictors, α the intercept, and βs the slope parameter.

The predictors included months of interview and were controlled for states. Finally, the logistic model was used to predict the probability of wasting at the national level. For this purpose, important clues were obtained through predicted probabilities of wasting for a particular month by holding all other months at their mean level. Analyses were carried out in the Stata version 16 software. Results were presented at the 95% confidence interval (CI).

3 | RESULTS

Figure 1 shows the prevalence of episodes of diarrhea among under-5 children during 2 weeks before the month of the interview. It was found that episodes of diarrhea in NFHS-5 were higher during the monsoon season, which contributed to the increased prevalence of wasting during the same period. The prevalence of diarrhea was highest in the months of April and December in NFHS-3 and relatively high in the months of July and September in NFHS-5.

The prevalence of wasting across different months of the year during NFHS-3, NFHS-4, and NFHS-5 is shown in Table 2. On the other hand, Table 3 shows the odds ratio (OR) of wasting among children under age 5 years by months of the surveys as revealed by the logistic regression analysis after controlling the effect of states.

The highest prevalence of wasting during NFHS-3 was recorded in May (28%) and the lowest was in December (13%). On the other

TABLE 2 Prevalence of wasting across months for NFHS-3, NFHS-4, and NFHS-5.

Month	NFHS-3		NFHS-4		NFHS-5	
	No. of children surveyed	% of children wasted	No. of children surveyed	% of children wasted	No. of children surveyed	% of children wasted
January	8170	15.3	5302	14.2	34,992	15.9
February	7578	16.3	29,500	15.5	39,529	16.3
March	5537	18.4	40,131	18.5	28,075	17.0
April	4918	22.2	47,427	19.4	9070	18.4
May	7971	27.5	48,654	23.2	28	6.9
June	8526	26.8	42,106	24.6	218	24.8
July	4952	22	23,786	22.7	16,955	24.2
August	507	14.2	8449	25.9	21,360	22.7
September	-	-	5488	26.8	25,672	21.9
October	-	-	3222	27.4	22,595	20.2
November	-	-	3147	20.8	15,681	18.5
December	3387	13.2	2415	18.0	18,745	20.4
Total	51,555	19.8	2,59,627	21.0	2,32,920	19.2

TABLE 3 Unadjusted and adjusted odds ratio (95% CI) of wasting levels across months for NFHS-3, NFHS-4, and NFHS-5.

	Unadjusted 95% CI									Adjusted 95% CI[a]								
	NFHS-3			NFHS -4			NFHS-5			NFHS-3			NFHS-4			NFHS-5		
Month	UOR	[95% CI]		UOR	[95% CI]		UOR	[95% CI]		AOR	[95% CI]		AOR	[95% CI]		AOR	[95% CI]	
January ®																		
February	1.10	0.99	1.21	1.16	1.06	1.27	1.03	0.97	1.10	1.11	1.00	1.22	1.21	1.10	1.33	1.02	0.95	1.08
March	1.24	1.12	1.37	1.39	1.27	1.52	1.09	1.02	1.17	1.29	1.15	1.43	1.48	1.35	1.63	1.08	1.02	1.17
April	1.35	1.22	1.50	1.52	1.39	1.67	1.19	1.08	1.33	1.71	1.47	1.99	1.66	1.51	1.82	1.17	1.06	1.30
May	1.52	1.39	1.66	1.88	1.72	2.05	0.39	0.09	1.79	2.02	1.67	2.46	2.08	1.90	2.29	0.35	0.07	1.66
June	1.42	1.30	1.55	2.03	1.86	2.22	1.75	1.23	2.49	2.15	1.77	2.62	2.34	2.12	2.57	1.34	0.93	1.95
July	1.41	1.27	1.56	1.82	1.66	2.00	1.69	1.58	1.82	2.43	1.97	2.99	2.30	2.08	2.54	1.47	1.35	1.60
August	0.98	0.74	1.29	1.76	1.59	1.95	1.56	1.39	1.75	2.49	1.76	3.53	2.56	2.29	2.86	1.37	1.22	1.53
September	-	-	-	1.95	1.74	2.17	1.49	1.39	1.6	-	-	-	2.28	2.02	2.57	1.32	1.21	1.44
October	-	-	-	2.00	1.77	2.26	1.34	1.23	1.46	-	-	-	2.12	1.85	2.44	1.24	1.13	1.36
November	-	-	-	1.60	1.4	1.82	1.20	1.10	1.32	-	-	-	2.17	1.89	2.48	1.08	0.98	1.20
December	0.83	0.73	0.95	1.31	1.14	1.52	1.360	1.25	1.48	0.82	0.71	0.93	1.77	1.52	2.06	1.32	1.22	1.44

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; UOR, unadjusted odds ratio.

[a]Adjusted for state variable.

hand, in NFHS-4, the prevalence of wasting was the highest in October (27%) and the lowest in January (14%). In NFHS-5, the highest prevalence was recorded in June (25%), while the lowest was recorded in January (16%). Thus, it can be asserted that there was a two-fold fluctuation within the year in each of the NFHS rounds. A two-fold increase in the prevalence of wasting was observed during August between NFHS-3 and NFHS-4. The prevalence of wasting was observed to be higher during the summer and rainy seasons. In NFHS-3, wasting was higher during April–July compared to the other months of the survey, whereas in NFHS-4, it was higher during the months of August–October. It is to be mentioned that in NFHS-3, no data was collected during the months of September–November and hence NFHS-4 and NFHS-5 observed a relatively higher prevalence of wasting. Thus, a dual reporting error was evidenced, that is, an underestimation of the prevalence of wasting in NFHS-3 and an overestimation in NFHS-4 and NFHS-5.

TABLE 4 Prevalence of wasting among children aged under 5 years in 12 selected states, India during NFHS-3, NFHS-4, and NFHS-5.

	NFHS-3				NFHS-4				NFHS-5			
			[95% CI]				[95% CI]				[95% CI]	
State	No. of children	Percent wasted	Lower	Upper	No. of children	Percent Wasted	Lower	Upper	No. of children	Percent wasted	Lower	Upper
Andhra Pradesh	1797	12.3	10.5	14.4	4628	17.6	16.4	18.8	10,151	18.3	17.1	19.5
Assam	1232	13.6	11.7	15.7	8855	17.0	16.1	17.9	10,645	21.7	20.6	22.8
Bihar	2000	27.3	25.2	29.5	22,275	20.9	20.3	21.5	21,040	22.9	22.0	23.8
Gujarat	1357	18.6	16.6	20.8	6444	26.5	25.2	27.9	9868	25.0	23.7	26.5
Jharkhand	1326	32.6	30.1	35.3	10,507	28.9	28.0	29.9	10,047	22.4	21.2	23.6
Karnataka	1456	35.4	33.3	37.5	6308	25.9	24.3	27.5	8383	19.5	17.9	21.2
Madhya Pradesh	2563	35.4	33.3	37.5	21,272	25.8	25.2	26.5	16,280	18.9	18.0	19.8
Maharashtra	2234	16.3	14.5	18.2	7,990	25.5	24.1	27.0	9520	25.5	23.1	28.0
Odisha	1530	19.6	17.6	21.8	9728	20.4	19.5	21.3	8522	18.0	16.9	19.2
Rajasthan	1,704	20.5	18.7	22.5	14,916	23.0	22.3	23.7	14,643	16.8	15.9	17.8
Uttar Pradesh	5,266	15.0	13.9	16.0	36,465	17.9	17.5	18.4	35,766	17.3	16.7	17.9
West Bengal	2028	16.8	15.1	18.7	4810	20.2	19.0	21.5	5618	20.4	19.0	22.0
India	41,306	19.8	19.3	20.3	2,25,002	21.0	20.8	21.3	2,32,920	19.2	18.9	19.6

Abbreviation: CI, confidence interval.

The odds of wasting were significantly higher across all the months (except December in NFHS-3) as compared to January in each of the three NFHS rounds (Table 3). The adjusted logistic regression analysis (after controlling for states) showed higher odds of wasting across all the months than the unadjusted analysis in NFHS-3, 4, and 5. Noticeably, the odds of having wasted children were the highest in August in all three NFHS rounds [OR:2.5 (95% CI 1.76–3.53), OR:2.6 (95% CI 2.29–2.86), and OR:1.4 (95% CI 1.22–1.53) in the respective NFHS rounds].

NFHS-3 showed higher odds of wasting in the summer months, while data was not collected during the peak monsoon season. The odds were statistically significant for most of the months. The lowest odds of wasting were observed in the winter season in both the 3rd and 4th rounds. The adjusted odds ratio showed that in NFHS-3, the odds of wasting were lower in December (0.82 times, CI 0.71–0.93) compared to January, while in NFHS-4 and 5, the odds were lower for February (1.21, (95% CI 1.10–1.33) and 1.08 (95% CI 1.02–1.17), respectively) compared to January. It indicates that seasonality is an associated factor in the determination of the prevalence of wasting and could potentially cause bias in the overall estimates depending upon the timing of the survey.

Table 4 shows the prevalence of wasting among children under 5 in the selected states. It is evident from the table that the prevalence of wasting increased in India by one per cent between NFHS-3 and NFHS-4 (from 19.8% to 21.0%), while between NFHS-4 and NFHS-5, it decreased by 2%. Among the 12 selected states, 4 states (Madhya Pradesh, Karnataka, Bihar, and Jharkhand) showed a decline in wasting levels between NFHS-3 and NFHS-4 and had large parts of the survey conducted in similar months. The other 8 states showed an increase in the prevalence of overall wasting between NFHS-3 and NFHS-4. Four out of 12 states showed an increase in wasting between NFHS-4 and NFHS-5; out of them, three (Maharashtra, Andhra Pradesh, and Gujarat) did not have any data for the comparable months. In fact, in these 3 states, NFHS-3 was conducted predominantly in the summer season (February to May) and NFHS-5 predominantly in the monsoon season (June to September).

Table 5 shows the predicted probabilities of wasting among children under age 5 for a particular month by holding all other months at their mean level in NFHS-3, NFHS-4, and NFHS-5. The probabilities can give a picture of the prevalence of wasting when all the interviews are conducted in a particular month. It was found that in NFHS-5, the total wasting would have been 16% if all the interviews were conducted in January and February. Similarly, in NFHS-3, the total wasting would have been 15% if all interviews were conducted in January. The pattern that emerges from the predicted probabilities indicates that if the interviews were conducted during the summer and the monsoon (April–September), the probability of children becoming wasted would have increased in every round of NFHS, but as the winter approaches, the prevalence of wasting clearly showed a declining trend.

4 | DISCUSSION

This study is the first attempt, to the best of our knowledge, to dissect the effect of seasonality and also to critically interpret the data contained on wasting in nationally representative surveys for a realistic comparison.

TABLE 5 Estimated probabilities of wasting by month of interview, India, 2005–2006, 2015–2016.

	NFHS-3 (2005–2006)	NFHS-4 (2015–2016)	NFHS-5 (2019–2021)
January	0.151 (0.149–0.154)	0.134 (0.134–0.135)	0.158 (0.158–0.159)
February	0.171 (0.168–0.173)	0.157 (0.157–0.157)	0.163 (0.163–0.164)
March	0.193 (0.189–0.197)	0.186 (0.185–0.186)	0.171 (0.17–0.171)
April	0.217 (0.211–0.222)	0.203 (0.202–0.203)	0.184 (0.183–0.186)
May	0.274 (0.269–0.279)	0.241 (0.24–0.241)	0.07 (0.058–0.082)
June	0.276 (0.27–0.282)	0.262 (0.261–0.262)	0.25 (0.239–0.261)
July	0.233 (0.227–0.239)	0.259 (0.258–0.259)	0.242 (0.24–0.243)
August	0.17 (0.157–0.183)	0.279 (0.278–0.28)	0.227 (0.225–0.229)
September	-	0.257 (0.256–0.258)	0.219 (0.218–0.22)
October	-	0.244 (0.244–0.245)	0.202 (0.201–0.203)
November	-	0.248 (0.247–0.249)	0.185 (0.183–0.187)
December	0.142 (0.138–0.146)	0.213 (0.212–0.213)	0.205 (0.203–0.206)

Note: Adjusted for state variable.

The present paper analyzed the unit-level data of NFHS-3, NFHS-4, and NFHS-5 to understand the impact of seasons on the overall prevalence of wasting in India by state and to examine month-wise trends. We found that wasting in India increased by one per cent from NFHS-3 to NFHS-4 at the national level but declined by 2% from NFHS-4 to NFHS-5. Given that wasting is known to be influenced by season, the timing of conducting the survey and the proportion of children covered in the different seasons during the surveys could influence the wasting levels and, thus, their comparability across the surveys.[13,20] Using the logistic analysis, we found that seasonality significantly influenced the prevalence of wasting across all three rounds of NFHS. It was observed that compared to the month of January, the odds of wasting were particularly higher in the summer and the monsoon seasons, especially in August, across all three rounds, which indicates an influence of seasonality in the prevalence of wasting in the country. The predicted probabilities corroborated with the above findings, indicating a high prevalence of wasting had the interviews been conducted during the summer and monsoon, (April to September) compared to the winter season (November to February) across every round of NFHS. The increase in the prevalence of infectious diseases like diarrhea during these seasons could be one of the predictors explaining the high prevalence of wasting during these seasons.[15] Previous studies suggest a significant association between wasting and diarrhea, especially among younger children aged 2–3 years.[26,27] There is a concomitant occurrence between wasting, stunting, and diarrhea. Dehydrating diarrhea is reported more frequently (69%) among children with severe wasting and severe stunting than among children with severe wasting (55%) or severe stunting (43%).[28] A recent study in Odisha, India found that around 24% of children suffered from wasting during the monsoon season as compared to only 16% in the winter season.[24] A study in Bangladesh also showed that the prevalence of wasting was the highest during the rainy season and before the harvest, and the lowest post the harvest season.[23] In African countries too, a significant association was found between seasonality and the nutritional status of children. Similar to our findings, a study conducted in Somalia observed maximum wasting in the dry season, followed by the rainy season. The study suggested climatic variation as a key driver which altered the nutritional status in the country.[9,14] Another study conducted in the African region also discusses the association between variation in season and the wasting prevalence among children.[29] Negative correlation has been found between the availability of food, exclusive breast feeding status, and wasting among children.[30] Food availability differs across the states and so does the nutrition status of children. The Indian State Hunger Index (ISHI) 2009 estimated food insecurity across 17 major states of India and found that 12 of the states fell in the "alarming" category and one state, that is, Madhya Pradesh fell into the "extremely alarming" category. The levels of wasting found in the present study for different states of the country correspond to the states' ISHI scores. For instance, Jharkhand, Bihar, Gujarat, Maharashtra, Madhya Pradesh, and Chhattisgarh scored high on ISHI and also had high levels of wasting across NFHS-4 and NFHS-5.[31] Seasonal variations have been observed in calorie intake and duration of breast feeding among children under 2 years in some regional studies too.[15]

The prevalence of wasting in the country needs to be interpreted in the context of seasonal changes[29] as seasonality affects many of the variables intrinsically related to child health and nutritional status. It is recommended that nutrition surveys be conducted at the same time (during similar months) each year so that direct comparisons can be made. The SMART methodology suggests the best practices for anthropometric data collection, recommends completing data collection within 1 month for a given domain and collecting data during the

same month(s) as in the former surveys to reduce the risk of seasonal bias when making a comparison across years.[32] States need to scale up prevention and treatment activities before the onset of the season when acute malnutrition increases. The wasting estimates can be corrected by controlling for potential seasonal bias. Accordingly, surveys must be encouraged to collect data on wasting during the same month every year to give more reliable estimates. Marshak et al.[33] suggest various study designs and analysis methods to ground our understanding of the seasonality of malnutrition, which includes drawing on participatory methods to identify community perceptions of seasonality, using longitudinal data and panel analysis with approaches borrowed from the field of infectious diseases, and linking the oscillations in nutrition data with climatic data.[33]

According to the Food and Agriculture Organization (FAO), the ailing sector of agriculture is the largest source of livelihood in India, with 70% of the country's rural population still relying primarily on it for survival. The changing dynamics in the climatic conditions have worsened food production in several parts of the country, which has resulted in severe seasonal wasting among children. In 2014–2015, India had a 12% deficit in rainfall, followed by a 14% shortfall in 2015–2016.[34] As per the Government of India, in 2016, 266 districts across 11 states were officially declared drought-prone. The water crisis in Maharashtra was at its peak in the year 2016, and the Maharashtra government declared a drought in over 29,000 villages in the state. It was the second straight year of drought, and most of the villages were in Marathwada and Vidarbha. Maharashtra experienced the highest rise (9%) in the prevalence of wasting from NFHS-3 to NFHS-4, followed by Gujarat (8%).

Focusing on seasonal hunger would be an effective way to leverage resources for the attainment of the hunger-related Sustainable Development Goal. India has adopted a number of nutrition programs during the last 45 years with the goal of reducing malnutrition. India has worked to improve the nation's nutritional position through the development of the Integrated Child Development Services (ICDS), the state-wide implementation of the mid-day meal program, and the enforcement of the National Food Security Act (2013).[35] Through a network of village-level centers, the Government of India's flagship program, Integrated Child Development Services (ICDS), offers health and nutrition services to children under the age of 6, adolescent females, and pregnant women. According to studies, ICDS's supplemental nutrition programs are a successful intervention for enhancing child nutrition outcomes.[36,37] The Government of India launched the National Food Security Act, 2013 with the goal of assuring access to sufficient quantities of high-quality food at reasonable prices by allowing up to 75% of rural and up to 50% of urban residents to receive subsidized food grains through the Targeted Public Distribution System (TPDS). Each month, qualifying individuals are allowed to get 5 kg of food grains at discounted rates of Rs. 3/2/1 per kg for rice, wheat, and coarse grains. The Act also places a particular emphasis on providing women and children with nutritional support. In addition to receiving meals during pregnancy and for 6 months following childbirth, pregnant women and nursing mothers are also eligible for maternity benefits worth at least Rs. 6000. Children up to the age of 14 have a right to wholesome meals that adhere to established dietary criteria.[35] The recipients get food security payments in the event that the required food grains or meals are not provided. The GOI has also introduced the Pradhan Mantri Matru Vandana Yojana (PMMVY) under the ICDS, the Anganwadi Service Scheme, and other programs to promote the health of women and children.

There are some limitations to this study. The first is that the duration of data collection was shorter for NFHS-3 as compared to the other rounds. This is because it collected data only at the state level, unlike the other rounds that collected data at the district level too. As it so happened, the period during which data was collected for NFHS-3 coincided with the season when the prevalence of wasting was low. Since NFHS-4 and NFHS-5 were designed to furnish data for the districts too, their sample sizes were large and it took more time to collect the data. The duration of data collection was spread across the year, including the months when wasting was at its peak. In some states, a large part of the NFHS-4 and NFHS-5 data was collected during the monsoon season, when wasting levels are at their peak.

5 | CONCLUSION

India is a signatory to the World Health Assembly that aims to reduce wasting levels below 5% by 2025. The narrative of progress around nutrition in India has been built around the fact that stunting and underweight have been reduced. But wasting has stagnated or worsened. This has created confusion among policy-makers and nutrition experts regarding how to explain and interpret the situation and what specific corrective actions to suggest. This paper highlights the role of seasonality in determining the levels and trends of wasting. The approach to tackling wasting should be cautious about the effect of seasonality on food security. Measures should be taken to aid the communities to protect themselves from increased vulnerability and become resilient in difficult months. The issues found in the Indian demographic surveys are also likely to be found in other countries with strong effects of seasonality. Thus global estimates of acute malnutrition must take this bias into account to analyze trends in the reduction of acute malnutrition. There needs to be global guidance of how nationally representative surveys on anthropometric indicators should be conducted. Ideally, the different rounds of any survey should be conducted in similar months to account for the impact of seasonality and to allow for comparability across the rounds. The WHO target of minimizing wasting levels to 5% needs further qualification to indicate whether such a target needs to be attained across every season. The government may consider some interventions for regions where the prevalence of wasting is perennially high, including mapping areas frequently affected by food insecurity and disruptions in the distribution of food and mobilizing the community through ASHA and Anganwadi workers during the periods of severe seasonal wasting.

AUTHOR CONTRIBUTIONS

Laxmi Kant Dwivedi: Conceptualization; data curation; formal analysis; methodology; writing – original draft; writing – review & editing. **Mrigesh Bhatia**: Conceptualization; funding acquisition; writing – review & editing. **Anjali Bansal**: Formal analysis; writing – review & editing. **Rahul Mishra**: Formal analysis; writing – review & editing. **Shirisha P.**: Writing – review & editing. **Somnath Jana**: Formal analysis; writing – review & editing. **S. V. Subramanian**: Writing – review & editing. **Sayeed Unisa**: Conceptualization; writing – review & editing.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The International Institute for Population Sciences, Mumbai was the nodal agency for conducting all rounds of NFHS surveys. All rounds of NFHS surveys are the anonymous, publicly available data set, and is accessible upon request from the DHS Program at https://dhsprogram.com/data/availabledatasets.cfm.

ETHICS STATEMENT

This analysis is based on a secondary data set with no identifiable information on the survey participants; the data set is available in the public domain for research purposes. Hence, no approval was required from any institutional review board as there was no question of human subject protection arising in this case.

TRANSPARENCY STATEMENT

The lead author Laxmi Kant Dwivedi affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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How to cite this article: Dwivedi LK, Bhatia M, Bansal A, et al. Role of seasonality variation in prevalence and trend of childhood wasting in India: an empirical analysis using National Family Health Surveys, 2005–2021. *Health Sci Rep*. 2023;6:e1093. doi:10.1002/hsr2.1093