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Article

Child health and unhealthy sanitary practices in India: Evidence from Recent Round of National Family Health Survey-IV☆

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ABSTRACT

Objectives: Despite threefold increase in investment (from Rs. 28,500 million to Rs. 90,000 million during 2014–17) in the allocation of funds for the Clean India movement, creating awareness and various social movements, more than half of the rural population (52.1%) of the country still defecates in the open. This study aims to examine the prevalence of improved sanitation facilities and safe stool disposal in India and its states. It also aims to further establish inter-linkages between safe stool disposal and child health.

Study design: The present study uses data from the fourth round of the recently conducted cross-sectional National Family Health Survey (NFHS-4, 2015–16).

Methods: Two proxy indicators used to assess the effect on child health are: stunting and mortality of children under the age of five years. Multivariate logistic regression analysis was employed to examine the impact of improved sanitation facilities and safe stool disposal on child health measured by height-for-age as a dichotomous variable. Multivariate discrete-time logistic model was used to examine the impact of improved sanitation facilities and safe stool disposal on under-five child deaths.

Results: The results reveal that unsafe disposal of stools are one of the main contributing factors responsible for stunting and under-five mortality among children. The prevalence was clearly seen to be higher in households where open defecation and unsafe stool disposal were practised.

Conclusions: The central behavioural change to be brought about among the people is to improve the cleanliness levels of the neighbourhood and help children spend their childhood free from the misery of malnourishment or in the worst case, death. It is not an impossible task for a country that houses the cleanest village in Asia, Mawlynnong in the Northeast state of Meghalaya, India. If one state could do it, it could be replicated in other states too.

Introduction

India's recent rapid macroeconomic development has not yet been translated into an improved public health scenario, especially in the case of child undernutrition. Studies argue that India's over dependence on "growth-mediated" policies to improve public health should be accompanied by a "support-led" approach that focusses on gaining in-depth knowledge of the mechanism and structural factors influencing the morbidity (Joe, Rajaram, & Subramanian, 2016; Subramanian, Mejía-Guevara, & Krishna, 2016).

The Government of India has designed the Clean India movement, "*Swachh Bharat Abhiyan*", by comprehending the need of extolling policies that address structural and mechanical causes of morbidities. There has been a threefold increase in investment (from Rs. 28,500 million to Rs.90,000 million during 2014–17) in the allocation of funds for the Clean India movement (*Swachh Bharat Abhiyan, Gramin*). The current Prime Minister of India, Mr. Narendra Modi, had launched the Swachh Bharat Mission, Gramin (SBM (G)) programme in 2014. Mr. Narendra Modi advocated the issue of sanitation in his election campaign. Thus, the government has prioritised sanitation in terms of policy attention as well as resource allocations. The target is to make India an open defecation free (ODF) country by 2019 (Ministry of Drinking Water and Sanitation, 2015).

Despite such a large investment, awareness creation and various social movements, more than half of the rural population (52.1%) of the country still defecates in the open (NSSO, 2016). At the global level, almost 2.4 billion people lack sanitation and 946 million practice open defecation (WHO-UNICEF, 2015). Almost 60 percent of open defecators

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Table 1
Percentage of Improved sanitation facility, Safe stool disposal, Stunting and Under five mortality rate per 1000 live births by states and UTs-2015-16.

	Improved sanitation facility	Safe stool disposal	Stunting[a]	Under five mortality rate per 1000 live births[b]	Sample size-no. of births	No. of women
North						
Delhi	62.1	72.1	32.1	42	1580	1258
Haryana	72.9	62.4	34.0	41	7882	5719
Himachal Pradesh	63.7	77.3	26.4	38	2929	2292
Jammu & Kashmir	43.4	52.0	27.7	38	8245	6280
Punjab	76.0	78.9	25.8	33	5216	4132
Rajasthan	35.2	29.9	39.1	51	16,832	11,950
Uttarakhand	58.4	62.4	33.9	47	5825	4298
Central						
Chhattisgarh	27.3	19.5	37.6	64	9283	6805
Madhya Pradesh	27.0	24.2	41.9	65	24,611	17,406
Uttar Pradesh	27.3	24.8	46.3	78	41,751	28,741
East						
Bihar	19.5	16.0	48.4	58	25,437	16,822
Jharkhand	18.0	19.0	45.5	54	12204	8947
Odisha	23.8	11.4	34.1	48	11,106	9015
West Bengal	42.4	39.4	32.7	32	5328	4459
North East						
Arunachal Pradesh	55.8	34.5	29.3	33	4966	3858
Assam	41.3	18.5	36.3	57	10,309	8534
Manipur	47.8	49.4	28.8	26	5636	4429
Meghalaya	56.9	35.0	43.9	40	4409	3119
Mizoram	79.8	73.4	27.9	46	4905	3681
Nagaland	70.2	53.6	28.5	37	4607	3136
Sikkim	83.5	97.8	29.4	32	1005	899
Tripura	54.8	53.3	24.0	33	1330	1169
West						
Goa	70.7	74.6	20.0	13	416	347
Gujarat	51.8	55.2	38.3	44	7730	5827
Maharashtra	43.4	48.1	34.2	29	9401	7143
South						
Andhra Pradesh	39.1	27.5	31.4	41	3128	2270
Karnataka	50.1	40.0	36.3	32	7789	5876
Kerala	94.4	91.5	20.0	7	2462	2128
Tamil Nadu	47.3	32.1	27.2	27	7922	6181
Telagana	43.8	39.7	27.6	32	2427	1785
UTs						
Andaman and Nicobar Islands	73.2	61.0	23.3	13	644	526
Chandigarh	66.9	82.2	29.2	38	194	150
Dadra and Nagar Haveli	24.7	40.1	41.8	42	322	244
Daman and Diu	65.5	74.2	23.1	34	407	331
Lakshadweep	98.0	84.1	26.6	30	308	262
Puducherry	63.9	38.6	23.8	16	1081	879
India	**38.7**	**33.6**	**38.4**	**50**	**2,59,627**	**1,90,898**

Note:
[a] Below -2 standard deviation.
[b] Based on five years from the date of survey.

in the world reside in India, mostly in rural parts (Planning Commission, 2013; WHO-UNICEF, 2014). Investments alone cannot be held responsible for reduction in the unsafe sanitary practices. Strong political will of the Administration, person to person social pressure and favourable political ecology are considered to be the “toilet tripod” that can accelerate successful adoption of health sanitation practices in India (O’Reilly & Louiss’, 2014). Open defecation is a traditional behaviour in India, especially in rural areas (Ghosh & Cairncross, 2014). The low rate of acceptance of improved sanitation facilities has widened the gap between availability and use of the sanitation facilities.

The issue creates greater concern as the percentage of population who openly defecates was higher among children less than 15 years (NSSO, 2016). Almost 57% children below 15 years in rural areas and 10 years in urban areas defecate in the open. This makes the child population more vulnerable to the collateral diseases associated with poor sanitary practices.

Poor sanitation facilities and open defecation area nuisance to the public health development of any country and are directly correlated with restricted growth in children which results in premature mortality (Spears, Ghosh, & Cumming,2013; Black et al. 2008). A growing body of literature has established that open defecation plays a key role in solving the puzzle of persistent childhood undernutrition in India (Chambers & Von Medeazza, 2013; Coffey, Deaton, Drèze, Spears, & Tarozzi, 2013). Although a few studies identify genetics as the reason for the short stature of Indian children (Panagariya, 2013) most researchers contradict this by claiming childhood stunting is strongly correlated with disease environment and open defecation.

There are three major pathways through which poor sanitation works as a catalyst in deteriorating child health, which may lead to premature death. These are through diarrhoeal diseases (Briend,1990), environmental enteropathy (Humphrey ,2009) and nematode infections (Prüss-Üstün & Corvalán, 2006). The relationship between diarrhoeal diseases and nutrition is not straightforward. Often households which are not practising safe stool disposal not only contaminate their own

household but also pollute the surrounding environment. When pathogen-ridden human faeces (Curtis, Cairncross, & Yonli, 2000) pass through the faecal-oral transmission route, they cause diarrhoeal diseases (Briend, 1990; Clasen et al., 2010). Eventually, repeated episodes of diarrhoea results in chronic malnutrition. Secondly, a study conducted in Gambia (Lunn, Northrop-Clewes, & Downes, 1991a, 1991b) shows that growth failure had an association with an indicator of subclinical intestinal permeability known as environmental enteropathy. This may be a primary causal pathway from poor sanitation to stunting (Humphrey, 2009). The third causal pathway through which poor sanitation affects child health is soil-transmitted helminthic infections, such as Hookworm, Ascaris Lumbricoides and Trichuris Trichiura. This results in the malabsorption of nutrients and growth retardation or failure (O'lorcain & Holland, 2000). Evidence suggests that availability and use of toilet facilities reduces the infections related to soil-transmitted helminthic infection and confirms the third causal pathway (Strunz et al., 2014; Ziegelbauer et al., 2012).

A wide range of literature addresses how safe and hygienic sanitary practices affect the health outcomes of children, especially in areas of high population density such as India. Many community-level differences in child health outcomes in India were found to be affected by sanitation practices (Nandi, Megiddo, Ashok, Verma, & Laxminarayan, 2017; Hathi, Haque, Pant, Coffey, & Spears, 2017; Geruso & Spears, 2015; Spears, 2013). However, there were only limited studies that estimated the influence of safe stool disposal and improved sanitation facilities on child health. So, this paper goes beyond examining the contribution of open defecation in many ways. In the demographic and health survey data, the place and distance from household to where people go to defecate is not available. So, a child's safe stool disposal has been considered a factor for the present study. This study aims to examine the prevalence of improved sanitation facilities and safe stool disposal in India and its states. Inter-linkages between safe stool disposal and child health have also been established in this study. Two proxy indicators used to assess the effect on child health are: stunting and mortality of children under the age of five years. This study also estimates the advantage of practicing safe and hygienic sanitation in terms of reduction in the number of stunted children and also number of deaths of under-five children.

Methods

Data sources: Sample size and design

The present study uses data from the fourth round of the recently conducted National Family Health Survey (NFHS-4, 2015-16). NFHS-4 provides information on population, health and nutrition for India and each State/Union Territory. The survey for the first time provides district-level estimates for many important indicators and has gathered information from 601,509 households, 699,686 women, and 103,525 men. The present study uses data of those births, which took place five years preceding the date of survey. This study uses 259,627 births of children born to 190,898 women at the India level. The general description of the data is provided in Table 1.

Measuring child health

Child health is measured using two indicators: stunting (low height for age) and under-five child deaths. According to the Child Growth Standards of the World Health Organization, stunting is defined as a height for age below minus 2 standard deviations (SD) of the median height for age (WHO,2006). Stunting has been coded as a binary variable with 0 representing z-scores above minus 2 standard deviations and 1 otherwise. Multivariate logistic regression analysis has been employed to examine the impact of improved sanitation facilities and safe stool disposal on child health measured by height-for-age as a dichotomous variable.

The second dependent variable of interest is under-five child deaths. To identify premature death, the births, which took place five years preceding the survey, have been taken for the analysis. This data is available in the birth history file. The time period of each interval is recorded in the NFHS survey to the nearest completed months, so the discrete-time approach has been used. Multivariate discrete-time logistic model has been employed to examine the impact of improved sanitation facilities and safe stool disposal on under-five child deaths.

In a discrete-time survival analysis, assuming time was divided into k intervals $\{I_t = [a_{t-1}, a_t)\}$ with $0 = a_0 < a_1 < \ldots < a_k < \infty$. The length of the interval may be unequal and censoring happen at the end of the intervals. Let the discrete time $T = t$, $t \in \{1, 2, \ldots, 60\}$ indicate the observed event in months after birth in the interval I_t. Suppose further that $x_{it} = (x_{1t}, \ldots, x_{rt})$ denote a vector of covariates. The conditional probability of death in the interval $[a_{t-1}, a_t)$ could be computed easily. The event of death of the ith child could be considered as a sequence of binary outcomes and can therefore be cast into the framework of binary regression models (Fahrmeir and Tutz, 2001) by defining a binary event indicator y_{it}. y_{it} has been linked to the covariates x_{it} by logit link function and predictor x_{it} as a function of discrete time t and the covariates.

The independent variables taken for the regression are described below.

Predictor variables

The major predictor variables of interest for the present study are improved sanitation facilities and safe stool disposal. Improved sanitation facility is created based on the question "What kind of toilet facility do members of your household usually use?" The response of the head of the household to the following options were, flush to piped sewer system, flush to septic tank, flush to pit latrine, ventilated improved pit (VIP)/biogas latrine, pit latrine with slab, twin pit/composting toilet, not shared with any other household were considered as improved sanitation facilities otherwise it was considered as a household member not practicing improved sanitation facilities. The child's mother has been questioned about the variable of safe stool disposal. For each surveyed woman, the question asked was "The last time child passed stools, what was done to dispose of the stools?" If women reported that they used toilet/latrine or put/rinsed in toilet/latrine or buried for disposing the stool it was considered as safe disposal of stools. If she put/rinsed into drain or ditch or threw into garbage or left in the open/not disposed of it was considered unsafe disposal of stools. Household, mother and child level independent variables which were considered in this model were region and place of residence where mother lives, sex and age of the index child, mother's age at birth and body mass index, caste and religion of mother, previous birth interval, mother's education and wealth index created by household assets. These independent variables were adjusted in the regression model to find out the net impact of improved sanitation facilities and safe stool disposal on child health outcomes.

Results

Patterns of practicing improved sanitisation and safe stool disposal

Table 1 shows the percentage of households using improved sanitation facilities (ISF), and safe practices for stool disposal. It also gives a picture of stunting and the under-five mortality rate (U5MR) per 1000 live births in Indian states and UTs for 2015–16.

The results shows a surprising situation overall as only 38% of households reported to be using ISF in India and about one third of households were following safe stool disposal practices. A stark statewise difference in the performance emerged from the bivariate analysis. In Kerala, one of the demographically advanced states in South India almost 95% of households were found to be practicing ISF, followed by

Sikkim and Mizoram in northeast India and Punjab in the north with 84%, 80% and 76% of households, respectively. Half of the states in India are still under 50% coverage of ISF. The situation in the central and eastern region was found to be the gloomiest as states in these two regions except West Bengal (42.4%) have not even attained 30% of ISF coverage. Jharkhand (18%), Bihar (19.5%), Odisha (23.8%) in the east and Madhya Pradesh (27%), Chhattisgarh (27.3%) and Uttar Pradesh (27.3%) in the central region being the poorest performers among all the states. Among the union territories (UT), Lakshadweep was the best performer with 98 percent coverage of ISF while Dadra and Nagar Haveli, with 25% of households was the poorest. This presented the wide contrast within India. However, there is less discrepancy in safe practices for stool disposal. Most of the states, which performed well in ISF coverage, have also done well in this indicator except Puducherry with 39% of households adopting safe stool disposal practices as against to 64% coverage of ISF. Four states Kerala, Sikkim, Mizoram and Punjab and UT Lakshadweep with highest ISF coverage have also performed well in the adoption of safe stool disposal practices. Sikkim performed the best at 98 percent, followed by Kerala (91.5%), Lakshadweep (84.1%), Punjab (78.9%) and Mizoram (73.4%). In the case of safe stool disposal also, the eastern and central regions performed poorly with Odisha being the lowest at 11 percent of households practising safe stool disposal. In addition to these regions, states in other regions such as Assam (18.5%) in the northeast, Andhra Pradesh (27.5%) in the south and Rajasthan (29.9%) in the north were also among the poorest performers in terms of adopting safe stool disposal practices. Overall, the situation for using ISF and safe stool disposal practices was found to be far from satisfactory.

Table 2
Percentage of Stunting and Under five mortality rate per 1000 live births according to Improved sanitation facility and Safe stool disposal by different states and UTs of India, 2015–16.

State	Stunting[a]						Under five mortality rate[b]					
	Improved sanitation facility			Safe stool disposal			Improved sanitation facility			Safe stool disposal		
	Yes	No	Relative change	Yes	No	Relative change	Yes	No	Relative change	Yes	No	Relative change
North												
Delhi	27.6	40.7	−32.2	30.0	39.3	−23.5	33	57	−42.3	28	30	−7.0
Haryana	31.1	43.6	−28.7	31.3	38.6	−19.0	30	69	−57.0	22	34	−35.1
Himachal Pradesh	24.0	31.8	−24.5	26.0	28.2	−7.8	42	40	4.8	25	14	74.4
Jammu & Kashmir	21.9	32.4	−32.4	23.5	32.4	−27.3	28	66	−57.0	19	54	−63.9
Punjab	23.6	34.7	−31.8	25.2	28.0	−10.2	30	40	−26.3	19	14	35.8
Rajasthan	32.4	44.1	−26.7	30.5	42.8	−28.8	44	57	−23.6	27	36	−26.0
Uttarakhand	31.2	37.9	−17.7	31.3	38.3	−18.1	43	58	−26.1	29	34	−12.6
Central												
Chhattisgarh	31.9	39.9	−20.1	29.7	39.6	−25.0	43	75	−42.5	28	44	−37.4
Madhya Pradesh	33.3	46.0	−27.7	35.9	43.9	−18.4	45	71	−36.9	35	47	−25.2
Uttar Pradesh	36.1	51.6	−30.1	38.4	48.9	−21.6	60	88	−32.0	41	57	−28.0
East												
Bihar	35.8	52.1	−31.2	41.3	49.7	−16.9	46	61	−24.1	29	43	−31.8
Jharkhand	33.1	49.0	−32.6	34.1	48.2	−29.2	42	59	−29.4	23	41	−43.9
Odisha	24.5	37.7	−35.1	24.3	35.4	−31.5	30	56	−46.8	9	31	−71.1
West Bengal	28.1	37.3	−24.9	27.1	36.4	−25.6	28	39	−28.0	15	23	−33.5
North East												
Arunachal Pradesh	25.7	33.7	−23.7	24.3	32.0	−24.0	26	51	−50.3	8	24	−66.1
Assam	29.6	41.4	−28.6	30.2	37.6	−19.7	45	65	−30.6	29	35	−16.7
Manipur	27.0	30.7	−11.8	25.8	31.7	−18.7	24	25	−1.2	9	21	−56.6
Meghalaya	43.0	45.0	−4.4	46.1	42.7	7.9	51	36	44.5	20	29	−30.5
Mizoram	26.4	34.8	−24.1	28.3	26.7	6.0	41	73	−43.9	25	26	−4.3
Nagaland	28.4	29.0	−2.3	29.6	27.3	8.4	42	53	−22.1	30	27	11.7
Sikkim	29.0	31.7	−8.3	29.6	25.4	16.2	34	20	73.9	10	0	
Tripura	20.8	28.4	−26.8	22.7	25.5	−10.8	27	45	−39.7	11	28	−62.1
West												
Goa	17.6	27.6	−36.3	18.9	23.2	−18.8	14	14	−3.8	9	21	−59.3
Gujarat	32.0	47.3	−32.3	32.7	45.3	−27.8	35	56	−37.9	16	38	−56.5
Maharashtra	29.5	39.0	−24.3	29.4	38.8	−24.2	18	40	−54.4	15	27	−42.7
South												
Andhra Pradesh	25.8	37.8	−31.8	25.7	33.6	−23.5	35	43	−18.9	14	30	−52.6
Karnataka	31.0	43.9	−29.3	29.6	40.7	−27.3	34	40	−13.4	12	27	−53.8
Kerala	19.7	40.8	−51.8	20.1	19.1	5.4	11	4	135.3	6	12	−47.8
Tamil Nadu	23.4	30.7	−23.6	22.3	29.5	−24.6	39	51	−24.1	9	41	−77.8
Telagana	21.5	34.4	−37.6	21.9	31.3	−30.1	14	47	−70.6	5	21	−75.1
UTs												
Andaman and Nicobar Islands	19.2	37.8	−49.1	19.1	30.0	−36.3	5	23	−80.2	3	7	−56.8
Chandigarh	26.2	32.8	−20.3	30.5	23.4	30.6	39	35	10.3	18	31	−40.4
Dadra and Nagar Haveli	23.4	48.6	−51.9	32.2	48.3	−33.2	11	49	−77.8	8	37	−77.5
Daman and Diu	21.3	27.6	−22.8	21.8	27.6	−21.1	16	68	−76.3	9	35	−74.5
Lakshadweep	26.7	0.0		23.9	41.0	−41.7	28	0		20	0	
Puducherry	25.2	20.7	21.9	23.8	23.8	0.3	13	31	−59.9	3	18	−82.9
India	**29.7**	**44.8**	**−33.6**	**30.4**	**42.4**	**−28.2**	**36**	**62**	**−41.5**	**21**	**40**	**−46.6**

Note:
[a] Below -2 standard deviation.
[b] Based on five years from the date of survey.

Table 3
Percentage of Stunting and Under five mortality rate according to Improved sanitation facility and Safe stool disposal by selected characteristics, India, 2015–16.

Background characteristics	Stunting[a]						Under five mortality frate[b]					
	Improved sanitation facility			Safe stool disposal			Improved sanitation facility			Safe stool disposal		
	Yes	No	Relative change	Yes	No	Relative change	Yes	No	Relative change	Yes	No	Relative change
Place of residence												
Urban	27	39	−29.3	28	36	−22.4	29	52	−44.24	18	36	−49.1
Rural	32	46	−31.1	33	44	−24.5	42	64	−34.14	25	41	−40.1
Education												
No education	44	52	−15.0	46	52	−10.7	61	72	−16.11	37	48	−22.3
Primary	37	46	−19.2	38	45	−15.0	56	62	−10.50	36	44	−16.8
Secondary	29	37	−23.7	29	36	−19.8	33	50	−35.17	18	33	−45.9
Higher	19	27	−28.9	19	24	−21.7	19	52	−62.54	10	27	−62.5
Religion												
Hindu	29	45	−34.7	30	42	−28.7	36	62	−41.52	21	40	−47.4
Muslim	33	46	−27.7	33	44	−24.8	37	63	−40.87	24	43	−43.4
Others	25	41	−38.1	26	38	−31.2	30	46	−35.09	18	29	−38.5
Caste												
SC	34	47	−28.9	35	46	−24.1	44	65	−31.67	26	44	−41.2
ST	36	47	−23.4	38	45	−16.5	45	62	−26.82	23	41	−43.8
Others	28	43	−34.7	29	41	−29.2	34	61	−44.39	20	38	−47.3
Wealth index												
Poorest	48	52	−8.1	51	52	−1.3	62	73	−15.73	37	49	−24.4
Poorer	41	44	−7.2	40	44	−10.2	58	61	−5.19	35	41	−14.1
Middle	35	38	−7.0	35	37	−6.0	42	53	−20.70	25	34	−24.7
Richer	28	32	−10.9	28	30	−5.4	37	38	−3.21	19	35	−45.1
Richest	22	24	−9.1	22	24	−8.5	22	30	−25.52	13	18	−28.7

Note:
[a] Below -2 standard deviation.
[b] Based on five years from the date of survey.

Distribution of stunting and under-five mortality

Overall 39% of children below the age of five in India were stunted. Bihar (48.4%) with almost half of the children stunted was the worst performing state, followed by Uttar Pradesh, Jharkhand, Meghalaya and Madhya Pradesh with 46.3%, 45.5%, 43.9% and 41.9% children stunted, respectively. States like Kerala and Goa, which have performed satisfactorily in case of health sanitary practices and other social indicators, were observed to have 20% of stunted children. Among the UTs, Dadra and Nagar Haveli had the highest percentage of children stunted and almost one fourth of children in all other UTs were found to be stunted. Uttar Pradesh was reported to have the highest U5MR, followed by Madhya Pradesh and Chhattisgarh. Kerala with an U5MR of seven displayed the lowest under-five deaths, followed by Goa with 13 under-five deaths per 1000 live births. Among the UTs, Andaman & Nicobar Islands and Puducherry witnessed the lowest under-five mortality with 13 and 16 under-five deaths for every 1000 live births. Dadra and Nagar Haveli observed the highest deaths among children less than age five as compared to other UTs.

Linkage between hygienic sanitary practices and degraded child health

Childhood stunting and healthy sanitation practices

Table 2 gives a state-wise comparative picture of stunting and U5MR by use of ISF and safe stool disposal practices.

Results show that in all the states barring a few, households, which have not used ISF, had a higher percentage of stunted children than those using them. In Bihar, Uttar Pradesh and Jharkhand, the percentage of stunted children was recorded to be the highest among those households not using ISF with almost half of the children reported to be stunted. In these states, around 30 percent less prevalence was observed in households with ISF as compared to households without ISF. Madhya Pradesh (46%), Rajasthan (44%) and Haryana (43%) came next in the line with high percentages of stunted children. In these states, households with ISF observed 27 to 29% less prevalence than those where ISF was not used. Overall, 45% children were reported to be stunted among those households, which have not used ISF as compared to 30% in households with ISF. The prevalence of stunted children in households with ISF was almost 33% less compared to those without ISF.

Bihar (49.7%), Uttar Pradesh (48.9%) and Jharkhand (48.2%) again recorded the highest percentages of stunted children in households not practicing safe stool disposal practices. While households in these states where safe stool disposal practices were adopted, the percentage of stunted children was 41, 38 and 34 respectively, amounting to a decrease of 17%–29% in the percentage of children stunted from households not following safe stool disposal. Gujarat, Madhya Pradesh and Rajasthan were also observed to have more than 40% of stunted children in households where safe stool disposal was not practised. If compared, households in these states, which adopted safe practices for stool disposal noted a decrease of 18%–29% in the prevalence of stunting in children from households which did not follow safe stool disposal practices. Overall a decrease of 28% was noted in the prevalence of stunted children between households following and not following the safe stool disposal practices with the latter being at a disadvantage.

Under five child mortality and health sanitation practices

The U5MR was the highest in the state of Uttar Pradesh for both categories of households. Households in Uttar Pradesh, which used ISF recorded 60 under-five deaths per 1000 live births in comparison to 88 under-five deaths among households, which did not use ISF. Chhattisgarh, Mizoram and Madhya Pradesh observed the second, third and fourth highest U5MR with 75, 73 and 71 respective under-five deaths per 1000 live births among households without ISF. These three states observed 42%, 44% and 37% lower under-five mortality respectively among households, which were using ISF at the time of the

survey. Looking at the overall situation, 42% decrease was noted in the under-five mortality in households using ISF with under-five mortality rate of 36 as compared to those not using ISF with U5MR of 62.

In all the states except a few, households, where safe stool disposal practices were adopted, recorded lower under-five mortality than those where safe practices were not followed. Uttar Pradesh reported the highest U5MR of 57 among households, which were not practising safe stool disposal, with a 28% decline in under-five mortality among safe stool disposal practising households. The same pattern was observed for most of the states. Odisha observed 71% less under-five deaths per 1000 live births for households where stools were disposed safely as compared to those households practising otherwise. The lowest change was observed in Mizoram where the decrease was only four percent in under-five deaths among safe stool practising households. Overall the situation shows 47 percent decline in under-five deaths for households following the safe practices as compared to those not following them.

Table 3 displays the prevalence of stunting in children and U5MR by use of ISF and safe stool disposal practices according to selected characteristics of household and women in India. It can be clearly seen from the results that across all the sub-population categories, the prevalence of stunting among children under the age of five and the U5MR were higher in households where ISF were not available and safe stool disposal practices were not followed. Children in rural areas, who belong to Muslim or SC/ST mothers with no education and from poorest households were the most stunted, but the situation worsened when there was a lack of ISF in the household and safe practices for stool disposal were not followed. In rural areas, 46 percent of children in households where there was no ISF were found to be stunted, and the prevalence was 44% in the case of unsafe stool disposal practices. Almost half of the children born to illiterate or less educated (up to primary level) women, who lived in households with no ISF and did not practice safe stool disposal, were recorded to be stunted. While a decline of 10%–20% was observed in the prevalence of stunting under these categories where ISF was available and safe stool disposal was practiced. Almost two in five children belonging to any category of religion were found to be stunted in households where ISF and safe stool disposal was not practised. A decrease of 17%–29% in stunting was reported in SC/ST households using ISF and safe practices for disposing stools as compared to those SC/ST households where they were not practised. As expected, children in rural areas, born to illiterate mothers and in SC/ST households experienced the highest under-five deaths as compared to other respective categories. The situation was found to be graver among those households where ISF was not utilised and stools were not safely disposed. More than 40% decline in deaths of children under age five per 1000 live births was observed in SC/ST or Muslim households practising safe stool disposal. Higher educated women, in those households where ISF was used and safe stool disposal practices were followed, experienced 63% less under five deaths in comparison to women with the same education levels belonging to households where there was no utilisation of ISF and safe stool disposal practices. The U5MR was the highest among poorest households where safe stool disposal practices were not followed but a decrease of one-fourth was witnessed in households practising safe disposal of stools.

Table 4 shows the effect of ISF and safe stool disposal on child stunting in India and its states. At the country level an improved sanitation facility and safe stool disposal were significant predictors of childhood stunting in logistic regression models that adjusted for region

Table 4
Adjusted estimates of Improved sanitation facility and Safe stool disposal on Stunting and Under five mortality by states and UTs-2015-16.

State	Stunting						Under five mortality rate					
	Improved sanitation facility			Safe stool disposal			Improved sanitation facility			Safe stool disposal		
	Exp (b)	95% CI for Exp (β)		Exp (b)	95% CI for Exp (β)		Exp (b)	95% CI for Exp (β)		Exp (b)	95% CI for Exp (β)	
		L	U		L	U		L	U		L	U
North												
Haryana	1.10	0.96	1.27	1.15**	1.03	1.30	1.84***	1.54	2.21	0.96	0.81	1.13
Jammu & Kashmir	1.15**	1.00	1.32	1.24***	1.10	1.39	1.02	0.83	1.25	1.38***	1.16	1.63
Rajasthan	1.02	0.93	1.12	1.34***	1.22	1.48	1.18**	1.02	1.36	0.78***	0.68	0.89
Central												
Chhattisgarh	0.89	0.77	1.02	1.23***	1.06	1.42	1.41***	1.13	1.77	2.58***	1.97	3.37
Madhya Pradesh	1.11**	1.01	1.21	1.13***	1.04	1.22	1.18***	1.05	1.34	1.08	0.98	1.19
Uttar Pradesh	1.04	0.98	1.11	1.19***	1.12	1.27	1.15***	1.07	1.24	1.36***	1.27	1.47
East												
Bihar	1.08	0.99	1.18	1.10**	1.02	1.20	0.74***	0.65	0.84	1.31***	1.16	1.48
Jharkhand	0.97	0.85	1.12	1.38***	1.23	1.55	0.95	0.77	1.18	3.27***	2.56	4.18
Odisha	1.05	0.92	1.19	0.97	0.83	1.14	1.16	0.92	1.46	1.67***	1.21	2.30
West Bengal	1.06	0.91	1.23	1.24***	1.07	1.45	0.64***	0.47	0.88	0.93	0.68	1.27
North East												
Arunachal Pradesh	1.06	0.90	1.25	1.34***	1.14	1.58	4.96***	3.72	6.61	4.00***	2.99	5.36
Assam	1.11*	1.00	1.23	1.03	0.91	1.17	1.49***	1.27	1.74	0.88	0.73	1.05
West												
Gujarat	0.94	0.80	1.10	1.06	0.93	1.21	0.96	0.76	1.20	1.50***	1.22	1.83
Maharashtra	0.98	0.87	1.12	1.12*	0.99	1.26	1.89***	1.43	2.50	4.66***	3.48	6.23
South												
Andhra Pradesh	1.07	0.84	1.37	1.19	0.93	1.51	0.80	0.55	1.16	2.65***	1.70	4.12
Karnataka	1.16**	1.00	1.33	1.22***	1.08	1.39	0.27***	0.21	0.34	1.91***	1.54	2.38
India	1.03***	1.01	1.06	1.15***	1.12	1.17	1.20***	1.16	1.25	1.39***	1.35	1.44

Note: Region, place of residence, sex of the child, age of the child, mother's age at birth, mother's body mass index, caste, religion, previous birth interval, mother's education, wealth index, improved sanitation facility and safe stool disposal have been included in the model.

* $p < 0.10$,

** $P < 0.05$,

*** $p < 0.01$. L and U stands for lower and upper limit respectively.

and place of residence, caste and religion of household, economic condition of household address through wealth index, age and sex of the child, mother's age at birth, mother's body mass index and education and previous birth interval.

The odds ratio for unimproved sanitation facility was 1.03 (95% CI = 1.01–1.06), which shows that compared with household access to toilet facilities, unimproved sanitation facilities along with open defecation were significantly associated with childhood stunting. Selected state specific models shows that the absence of household sanitation facilities showed a significant positive association with stunting among children aged 0–59 months in the States of Jammu & Kashmir, Madhya Pradesh, Assam and Karnataka. Though after controlling the other factors in the model in the remaining twelve states households with improved sanitation facilities were not a predictor of child stunting.

The second model indicates a statistically significant association between unsafe disposal of children's stools and child stunting after adjusting for all potential children, mother and household related confounders. The adjusted odds ratio for unsafe stool disposal was 1.15 (95% CI = 1.12–1.17) and highlighted the 15% higher chance of being stunted compared to children whose stools were disposed of safely. The state specific model shows that all study states except for four states namely Odisha, Assam, Gujarat and Andhra Pradesh show that unsafe disposal of child faeces was significantly associated with increased odds of child stunting.

The last two columns of Table 4 show the effect of improved sanitation facilities and safe stool disposal practices on under-five mortality risks in India and the selected states. Overall the India level result shows that children living in a household with improved sanitation facilities have a mortality risk which is about 20% lower (95% CI = 1.16–1.25) than that of children living in households with unimproved sanitation facilities. For all study countries improved sanitation facilities appear protective for under five children, except for Jammu & Kashmir, Jharkhand, Odisha, Gujarat, and Andhra Pradesh.

Further, findings also show that the U5MR had a statistically significant association with unsafe disposal of children's stools. The odds of dying before completing five years of age was 39 percent higher (OR: 1.39; 95% CI: 1.35–1.44) in children whose stools were disposed unsafely compared to children whose stools were disposed safely. There were no synergistic effects of household with safe stool disposal practices and theU5MR in five study states namely Haryana, Madhya Pradesh, West Bengal and Assam.

Table 5 describes the probabilities of stunted children and under-five child deaths per 1000 live births by practice of safe stool disposal when all the remaining variables are controlled at their average level in the logistic model in case of stunting and discrete logistic model in case of under-five child deaths. The probabilities of stunted and under-five child deaths may help in finding if a change in relation to the practice of safe stool disposal is made possible and what additional gain may be expected in comparison to its prevailing average level. This additional gain can easily be obtained by subtracting the probabilities reported against a considered level of a variable from that reported against the average level. It is evident from the Table that the probability of stunted children decreases across all the states of India when households practice safe disposal of stools. The maximum reduction in stunting was found in Jharkhand followed by Rajasthan and Arunachal Pradesh. Moreover, all the selected states in the analysis show a decrease in stunting if it is assumed that the household practices safe disposal of stools.

The other crucial finding was that when it was assumed that all the households would dispose faeces safely, there was a significant reduction in the U5MR. Jharkhand, Chhattisgarh and Arunachal Pradesh show the maximum gain if they would practice the safe disposal of stools. Results show that larger states like Uttar Pradesh and Bihar also show significant improvement in the decrease in child deaths.

Discussion

The present study shows the effect of practicing improved sanitation

Table 5
Estimated probabilities of Stunting and Under-five child deaths by Safe stool disposal by selected states of India, 2015–16.

State	Stunting			Under five mortality rate per 1000 live births					
	Safe stool disposal			Improved sanitation facility			Safe stool disposal		
	Average	Yes	No	Average	Yes	No	Average	Yes	No
North									
Haryana	34.2	33.0	36.1	3.4	2.6	4.8	3.4	3.5	3.4
Jammu & Kashmir	28.5	26.4	30.4	3.1	3.1	3.1	3.1	2.6	3.5
Rajasthan	39.3	34.7	41.3	3.7	3.3	3.9	3.7	4.5	3.5
Central									
Chhattisgarh	38.4	34.6	39.3	4.2	3.2	4.5	4.2	1.8	4.7
Madhya Pradesh	42.5	40.4	43.1	5.2	4.5	5.3	5.2	4.9	5.2
Uttar Pradesh	46.5	43.6	47.5	6.1	5.5	6.3	6.1	4.8	6.5
East									
Bihar	48.8	46.9	49.1	4.4	5.7	4.2	4.4	3.5	4.6
Jharkhand	45.3	39.3	46.7	4.0	4.2	4.0	4.0	1.4	4.5
Odisha	35.2	35.7	35.1	3.3	2.9	3.3	3.3	2.0	3.4
West Bengal	34.1	31.1	35.7	1.6	2.2	1.4	1.6	1.7	1.6
North East									
Arunachal Pradesh	29.8	26.1	32	3.3	1.2	5.9	3.3	1.2	4.5
Assam	36.1	35.5	36.2	3.5	2.7	3.9	3.5	3.9	3.4
West									
Gujarat	40.2	39.5	40.8	3.2	3.3	3.2	3.2	2.5	3.7
Maharashtra	36.3	34.9	37.3	2.0	1.3	2.4	2.0	0.7	3.0
South									
Andhra Pradesh	33.9	34.8	31.5	2.4	2.7	2.2	2.4	1.2	2.9
Karnataka	38.6	35.6	40.1	2.2	4.0	1.1	2.2	1.5	2.8
India	38.6	36.6	39.5	3.8	3.4	4.0	3.8	3.0	4.1

Note: Region, place of residence, sex of the child, age of the child, mother's age at birth, mother's body mass index, caste, religion, previous birth interval, mother's education, wealth index, improved sanitation facility and safe stool disposal have been included in the model.

facilities and safe stool disposal on the prevalence of stunting and U5MR. Results reveal that unsafe disposal of stools is one of the important contributing factors responsible for stunting and under-five mortality among children. The prevalence was clearly seen to be higher in the households where open defecation and unsafe stool disposal were practised. The study is pertinent in highlighting that the disposal of stool, given its proximity to the households and surrounding areas, has a serious impact on child health outcomes in many states of India. In some states, open defecation did not emerge as a significant factor for stunting and under-five mortality due to the complexity involved in its relationship with the early age health outcomes. There is evidence that open defecation interacts with population density affecting child health outcomes (Hathi et al., 2017). Our study shows that open defecation and safe stool disposal practices have a major effect on childhood stunting and mortality in India. The present study raises vital questions on the linkage of sanitation habits and child health. Some serious data limitations are: the proximity to open defecation sites are not available and stool disposal habits of only the youngest child is available. Owing to the data limitation, the study missed an opportunity to adjust for these factors and further explore its relationship with stunting and under-five mortality in the state-specific analysis. Future research by using field data on use of toilet and stool disposal habit may strengthen the findings. The heterogeneous behavior of improved sanitation facilities can be accounted for by integrating field information on proximity of open defecation sites and frequency of unsafe stool disposal to the existing data. Sanitation is a multifaceted issue in a diverse country like India. Regional variations need deeper introspection through primary qualitative studies.

For India to realise the Sustainable Development Goal (SDG) of ensuring access to sanitisation for all by 2030, there is an array of factors that need to be addressed. In a country like India, only access does not ensure hygienic sanitation practices. An example is: the Total Sanitation Campaign (TSC) launched in 1999 (Sinha et al., 2017). This programme was aimed at making India Open Defecation Free ("Nirmal Bharat") by 2017. The obvious failure of this campaign is evident from this study. It was found that 64.3 million individual household latrines, including 34.8 million latrines in below poverty line households, were constructed as a part of TSC. Despite, this investment and efforts, a review of TSC suggested that almost 72.63% households in rural India defecate in the open even though they have access to latrines (Planning Commission, 2013). Keeping this in mind, the main aim of the Clean India movement (*Swachh Bharat Abhiyan, Gramin*) is to change the behaviour of the people through an Information, Education and Communication campaign and to provide sanitary toilet facilities in all the households so that India can achieve the goal of being open defecation free by 2nd October 2019- the 150th birth anniversary of Mahatma Gandhi. The central government also says, "It involves a change of mind-set amongst people to stop open defecation and to adopt safe sanitation practices." In this campaign the central government also emphasises the importance of safe sanitation practises by highlighting adverse health outcomes. However, The *Swachhta Status Report* finds that slightly less than half of rural households (45.3%) had access to a sanitary toilet, which ensures safe confinement and disposal of faeces.

Empirical evidence from our study points at the benefits of using improved sanitation facilities and practicing safe stool disposal in terms of reduction of childhood stunting and premature deaths. The general public, especially in rural India, should be made more aware about the risks of unhealthy sanitary practices. Movies by popular national actors like "*Toilet: Ek Prem Katha*" ("Toilet: a love story"), showcasing the negative implications of open defecation, should be promoted and screened in rural areas to make people understand the necessity of adopting safe and healthy sanitary practices. Local leaders should be educated to spread awareness. A few studies found that teachers and natural leaders from socially cohesive villages act as efficient mediators in encouraging behavioural changes in the population (Crocker, Saywell, & Bartram, 2017). The main behavioural change that needs to be brought about among people is to improve the cleanliness levels of the neighbourhood and help children spend their childhood free from the misery of malnourishment or in the worst case, death. It is not an impossible task for a country that houses the cleanest village in Asia, Mawlynnong in the northeast state of Meghalaya, India.

Author statements

Ethical approval

The unit level data from NFHS-4 is available in the public domain (International Institute for Population Sciences, ORC Macro ,2018).The survey was approved by the International Institute for Population Sciences (IIPS) Ethical Review Board in India. Data collection procedures were also monitored and approved by the ORC Macro Institutional Review Board. A standard consent form approved by the Ethics Review Committee was read out to the respondent in their native language.

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Competing interests

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