BMJ Open

Association of child health and household amenities in high focus states in India: a district-level analysis

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To cite: Gouda J, Gupta AK, Yadav AK. Association of child health and household amenities in high focus states in India: a district-level analysis. *BMJ Open* 2015;**5**: e007589. doi:10.1136/bmjopen-2015-007589

▸ Prepublication history for this paper is available online. To view these files please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2015-007589).

Received 7 January 2015
Revised 30 March 2015
Accepted 16 April 2015

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ABSTRACT

Objectives: To assess household amenities in districts of high focus states and their association with child health in India.

Design: The data for the study are extracted from Annual Health Survey (AHS) and Census 2011.

Settings: Districts in high focus states in India.

Participants: Information regarding children below 5 years of age and women aged 15–49 has been extracted from the AHS (2010–2011), and household amenities information has been obtained from the Census (2011).

Measures: Household amenities were assessed from the census at the district level in the high focus states. Child health indicators and wealth index were borrowed from AHS and used in this study to check their linkage with household amenities.

Results: Absence of drinking water from a treated source, improved sanitation, usage of clean cooking fuel and drainage facility in the household were adversely associated with the incidence of acute respiratory infection, diarrhoea, infant mortality rate (IMR) and under 5 mortality rate (U5MR). The mean IMR declined from 64 to 54 for districts where a high proportion of household have improved sanitation. The result of ordinary least square regression shows that improved sanitation has a negative and statistically significant association (β=−0.0067, p<0.01) with U5MR.

Conclusions: Although child healthcare services are important in addressing child health issues, they barely touch on the root of the problem. Building toilets and providing safe drinking water, clean cooking fuel and drainage facilities at the household level, may prevent a number of adverse child health issues and may reduce the burden on the healthcare system in India.

Strengths and limitations of this study

- The novelty of this study is that the unit of analysis is the household at the district level, which is a lower level factor compared with the state/province level.
- This study assumed that mere availability of any specific amenity will lead to its use; this may not be true in every case.
- This study considered availability of tap water from treated source at household as an explanatory covariate of child health.

INTRODUCTION

Every year, an estimated 3.7 million children worldwide die in the first month of life. Global progress in reduction of child mortality rates is insufficient—only 16 of 68 countries are likely to achieve Millennium Development Goal 4 (MDG 4: reduction of child mortality aged <5 by two-thirds between 1990 and 2015).[1 2] India has made gradual progress on child health indicators since 1990; however, the progress is not enough to achieve its national goal or MDG 4 by 2015.[3] India is home to the largest proportion of underweight children in the world and there is a high prevalence of neonatal, infant and child mortality.[4 5] The likely explanations include social inequities, disparities in health systems between diverse groups of population, and the impact of unplanned urbanisation and demographic transition.[6–8] Pneumonia and diarrhoea are the other leading comorbidities of child death as evident from a number of studies conducted worldwide. Several interventions can effectively address these problems, but they are not available to those in need.[7]

Being a large country, India is very diverse in its socioeconomic and demographic characteristics. Most of the southern states, including Goa and Maharashtra, are on track to achieve MDG 4 within the stipulated time, whereas the northern and other socioeconomically disadvantaged states record poor child health.[9 10] The education of the mother, age at birth, nutritional status, attendance at childbirth and spacing between childbirths are important covariates responsible for these interstate differentials.[10–12] In addition, the coverage gap in essential child health services and newborn care provided in primary health centres has been found to transpire as the other significant correlate of under 5 mortality in India.[13] India embarked

on its very ambitious health programme—the National Rural Health Mission (NRHM)—in 2005, to overcome the health infrastructure hurdles in rural areas. This flagship health programme paved the way to improve the health infrastructure and positioned competent health personnel in rural areas. Although the progress under this programme has been significant in improving the overall health status of children, the improvement is not uniform across the subgroups of population.[14 15] Studies have revealed that the poor economic condition of the household, parent's illiteracy and caste are major contributors to health inequalities among children in Indian states.[6 7]

RATIONALE OF THE STUDY

Given that child health in India is poor, a large number of studies have assessed the level and trend of child undernutrition, morbidity and mortality. The contribution of an inadequate healthcare system and that of individual covariates to child health has also been a focus in many studies in India. However, the understanding of household characteristics on child morbidity and mortality in disadvantaged states is scarce. In particular, knowledge on the association of household amenities on child health at the district level, in socioeconomically disadvantaged states, is very limited. This information is significant for planning and programme formulation at the district level, to address child health issues. Against this backdrop, the present study has made an effort to shed light on the association between household amenities, and child morbidity and mortality in districts of high focus states in India. On account of the unacceptably high fertility and mortality indicators, the eight Empowered Action Group (EAG) states (Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Orissa, Rajasthan, Uttarakhand and Uttar Pradesh) and Assam are designated as 'High Focus States' by the Government of India. The specific objectives for this study are listed below.

OBJECTIVES

1. To examine the proportion of households availing of essential amenities such as safe drinking water and improved sanitation facilities, at the district level in high focus states.
2. To document the relationship between selected household amenities, and child morbidity and mortality, at state and district levels.
3. To study the adjusted effect of selected household amenities and individual covariates, on child morbidity and mortality.

METHODS

Ethics statement

The study used data sets that are available in the public domain; thus, there was no requirement to seek ethical consent in this study.

Data

The study considered the nine high focus states in India, consisting of 284 districts. The district-level data for all nine states were collected from the recently concluded Annual Health Survey (AHS) 2010–2011 and Census 2011.

Realising the need for decentralised district-based health planning in India, the Office of the Registrar General, Government of India, implemented the AHS in all 284 districts (as per the 2001 census) of the eight EAG states and Assam (for a 3-year period) during the 11th 5-year plan period (2007–2012). These nine states, which account for about 48% of the total population in the country, are high focus states in view of their poor maternal and child health statistics, and high fertility rates. For the first time in the country, the survey provides district-level estimates on a set of child mortality indicators, including infant mortality rate (IMR), under 5 mortality rate (U5MR), neonatal mortality rate and postnatal mortality rate, in these high focus states. Further details of data collection and management procedures are available on the survey website (http://www.censusindia.gov.in/2011-Common/AHSurvey.html). The present study used the district-level estimates on IMR, U5MR, acute respiratory infection (ARI) and diarrhoea, provided by the AHS 2011 conducted during 2010–2011 in nine high focus states in India as outcome variables. Further, the household economic condition given in the AHS was used as a predictor determinant to check the variation in child health status.

The 15th Indian National Census was conducted by the Office of the Registrar General, Government of India, between February 9 and 28, 2011 (population enumeration phase). It was based on complete enumeration and was conducted in all 35 states and union territories of India. Census 2011 covered 640 districts and 5767 *talukas*. About 2.7 million officials visited households in 7935 towns and 640 867 villages. In the Census, information on a wide range of socioeconomic and demographic characteristics, at household and at individual level, is collected.[16 17] Information on household amenities, such as availability of drinking water from a treated source, usage of clean cooking fuel, and drainage and sanitation facilities, at the district level for the mentioned states, was used as predictor variables. Besides this, figures for female work participation and the proportion of rural population from the Census were considered as predictors to estimate their effect on child health.

Description of variables

The computational procedures or conceptual definitions of the variables used in this study are given below (in tabular format).

ANALYTICAL APPROACH

Descriptive statistics were used to estimate the proportion of households with essential amenities and their

Variables	Description	Source
Outcome		
Log IMR	Total infant deaths aged below 1 year per 1000 live births (infant deaths/total live births×1000)	AHS, 2010
Log U5MR	Total child deaths aged below 5 years per 1000 live births (child deaths aged below 5/total live births×1000)	AHS, 2010
ARI	The information on children suffering from ARI in respect of all the living children (last two outcomes of pregnancy(s) resulting in live births during the reference period, ie, 2007–2009) during 15 days preceding the date of survey has been collected	AHS, 2010
Diarrhoea	The information on children suffering from diarrhoea in respect of all the living children (last two outcomes of pregnancy (s) resulting in live births during the reference period, ie, 2007–2009) during 15 days preceding the date of survey has been collected	AHS, 2010
Predictor		
Female work participation	Total female workers irrespective of type of work/total female population×100	Census, 2011
Proportion of rural population	Total rural population/total population×100	Census, 2011
Wealth index	The wealth index is computed using household assets in AHS	AHS, 2010
Drainage facility	Includes both open and closed drainage available in a household	Census, 2011
Improved drinking water	Includes drinking water from a treated/untreated source, covered well and tube well/borehole/hand pump at the household level	Census, 2011
Drinking water from a treated source	Availability of drinking water from a treated source in a household	Census, 2011
Improved sanitation	Includes flush toilet, piped to a sewer system or a septic tank, and a pit with slab/ventilated improved pit	Census, 2011

association with selected child morbidity and mortality, at state and district levels. The ArcGIS software package was used to generate maps for the amenities indicators at the district level. Scatter plots were generated to check the association between household amenities and selected child morbidity and mortality. Ordinary least square (OLS) regression was carried out to check the adjusted and unadjusted effect of selected covariates on infant and child morbidity and mortality. This kind of analysis is extensively used while assessing mortality in India.[18]

The average number of child health indicators was estimated by districts divided into quintiles according to the proportion of households avail with basic amenities in ascending order. Improved sanitation, usage of clean cooking fuel and drinking water from a treated source were used as the proxy indicators of amenities to check their relationship with child health conditions. Three equal-interval quintiles were generated and labelled as 'Low', 'Middle' and 'High' to describe the level of amenities available at the household. After investigating the normality of residuals of IMR, U5MR and ARI using a graphical as well as non-graphical (Kernel density estimates and Shapiro-Wilk) test, it was observed that the distribution was not overtly skewed. Thus, the average (mean) of child health indicators can be considered as the appropriate summary statistic. This kind of analysis has already been used while assessing child health inequality with economic development by districts in India.[19]

RESULTS

In more than half of all the districts, less than 15% of households have improved sanitation and drinking water from a treated source. No more than four districts have 60% and above of households with drinking water from a treated source and only 17 districts have the same proportion of households with improved sanitation facility. In Uttar Pradesh, Bihar and Odisha, none of the districts have 60% and above of household with access to drinking water from a treated source and improved sanitation facility (figures 1 and 2).

The availability of improved sanitation facility at household and IMR are inversely correlated in the study. States having more households with improved sanitation facility record low prevalence of IMR. Uttarakhand has the highest coverage of households with improved sanitation facility and records lower IMR than any other high focus states. Madhya Pradesh, Odisha, Uttar Pradesh, Assam, Rajasthan, Chhattisgarh and Bihar have low coverage of households with improved sanitation facility and record higher prevalence of IMR than the national average. The correlation (−0.27) value also suggests a negative association between households with improved sanitation and IMR in the study (figure 3).

It is evident from figure 4 that households using clean cooking fuel record low incidence of ARI. Uttarakhand has the highest usage of clean cooking fuel at the household level and reports a low prevalence of ARI among children. The correlation (−0.58) value also suggests a

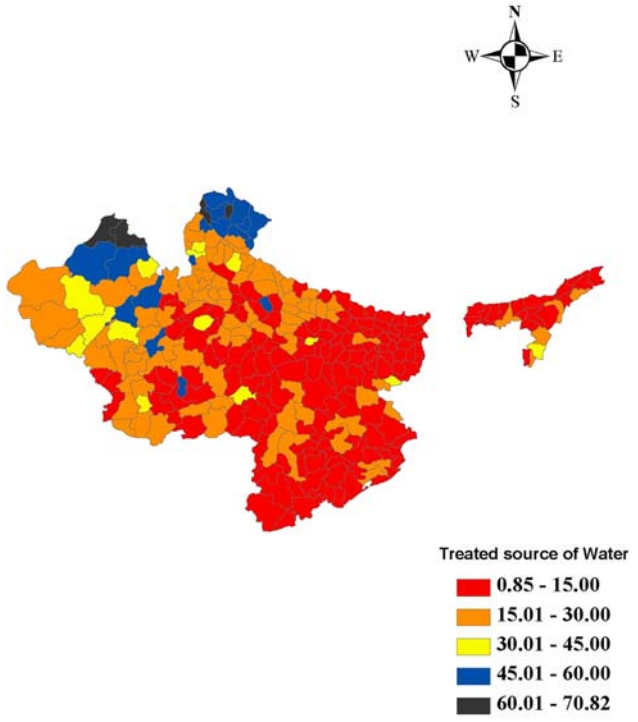

Figure 1 Percentage of households having drinking water from treated source, 2011.

strong negative relationship between usage of clean cooking fuel and incidence of ARI.

The scatter plots in figure 5 show the cross-sectional association and correlation matrix of nine selected

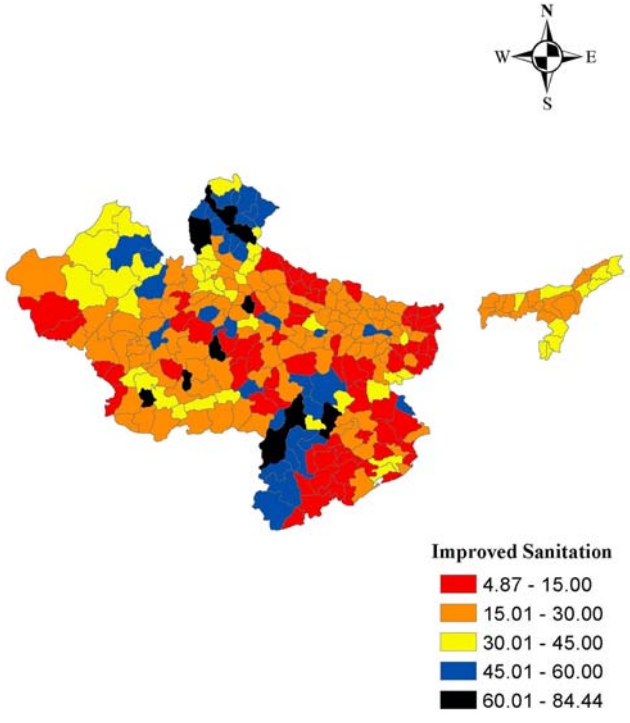

Figure 2 Percentage of households using improved sanitation, 2011.

indicators across 15 states for the year 2010–2011. The cross-sectional relationship between IMR/U5MR and its selected explanatory variables shows that the percentage of households in the lowest 20 percent wealth quintiles (WQs), diarrhoea and unclean fuel, shows a positive association with U5MR and IMR, meaning the decrease in diarrhoea and percentage of households in the lowest 20 percent WQs and increased use of unclean fuel will contribute positively towards the decline in U5MR/IMR in India. Similarly, improved sanitation, treated water sources and clean lighting in households show a negative relationship, which indicates that the increases in these factors will decrease U5MR/IMR levels in India.

Table 1 presents the summary statistics of the variables used in the study. This information is provided to explain the nature of the variables. In table 2, the raw correlation coefficient is given. The values of the correlation coefficient (r2) depict the association between dependent and independent variables. A lower value of correlation coefficient suggests that there is no multicollinearity among the variables used in the study.

At the district level, as the proportion of household with improved sanitation shifts towards high, the incidence of IMR and U5MR declines. The mean IMR for districts having a low proportion of households with improved sanitation is 64. This declines to 54 where a high proportion of households are provided with the above mentioned amenity. A similar pattern is also observed for U5MR. Households using unclean cooking fuel and ARI among children is positively correlated in the study. Incidence of ARI increases for districts where a high proportion of households use unclean cooking fuel. Districts having a low proportion of households with drinking water facility from a treated source record a high mean prevalence of diarrhoea (34%; table 3).

Table 4 presents the unadjusted and adjusted estimates from four OLS regression models that estimate the effect of household sanitation and socioeconomic factors on child health indicators. Models 1–3 report OLS results with robust SEs (to control for heteroskedasticity) in parentheses taking care of the multicollinearity problem. The significant values of F statistics for models 1–4 indicate that the overall model is statistically significant. The test of normality shows that the residuals are normally distributed, which is again confirmed by Kernel density estimates. A non-graphical test is also carried out using the Shapiro-Wilk test for normality. The higher the value of this test, the less the departure from normality for all the models. Though the R^2 value is relatively low, it is acceptable because the study included only household amenities and few socioeconomic covariates in the model. The adjusted R^2 given in the model adjusts for the number of explanatory terms and incorporates the model's degree of freedom. The mean variation inflation factor (VIF) values do not exceed 10, which signifies the non-existence of multicollinearity.

Model 1 shows that improved sanitation and female work participation has a negative and statistically

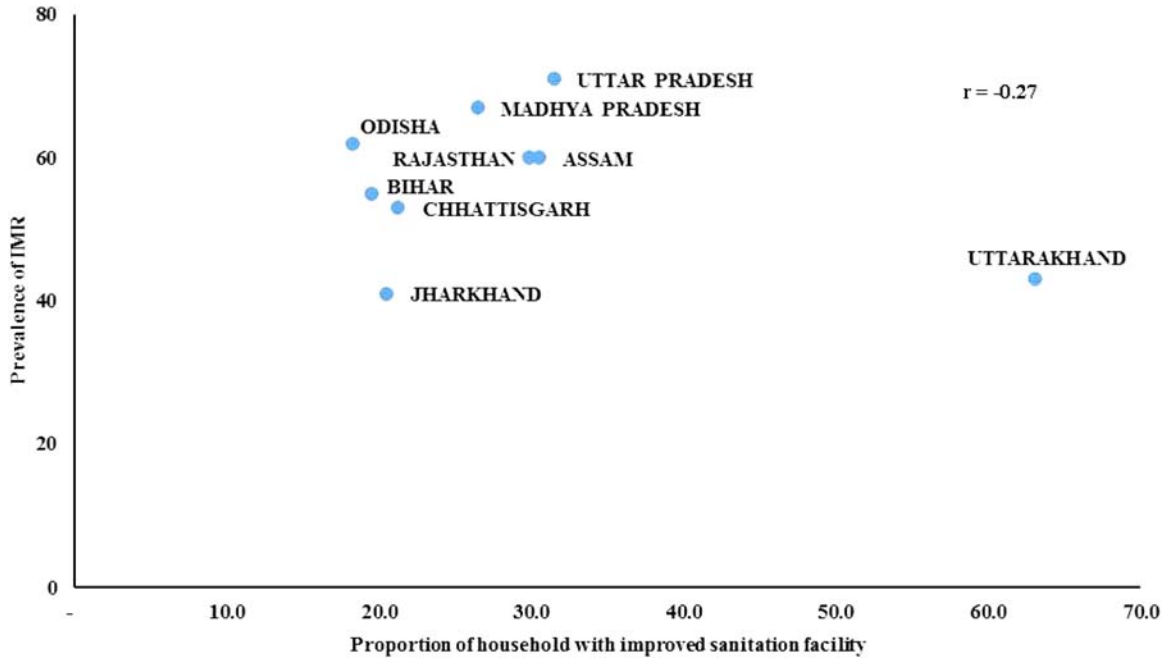

Figure 3 Infant mortality rate (IMR) by proportion of households with improved sanitation facility.

significant association (β=−0.0067, p<0.01; β=−0.0052, p<0.01) with U5MR. This indicates that improving sanitation will reduce the chances of death for those aged under 5 years. Unavailability of drainage facilities and percentage of people in the lowest 20 percent WQs are positively associated (β=0.0026, p<0.01; β=0.0081, p<0.01) with U5MR. Adjusted coefficient of the model does not significantly attenuate the association of sanitation, bottom WQs and rural population, with U5MR. In the adjusted model, availability of improved water, and diarrhoea, emerged as the other predictors of U5MR. Model 2 presents the unadjusted and adjusted estimates of the effect of the same set of explanatory variables on IMR. Improved sanitation, drinking water from a treated source and female work participation are negatively associated with IMR. Per cent of population in the lowest 20 percent WQs and unavailability of drainage facilities are positively associated with IMR. After adjusting for all the factors, improved sanitation and people in the lowest 20 percent WQs were found to be the main predictors of infant deaths. In model 3, it is observed that better sanitation practices, availability of treated water and increased use of a clean lighting source in the household, will reduce the incidence of ARI among children.

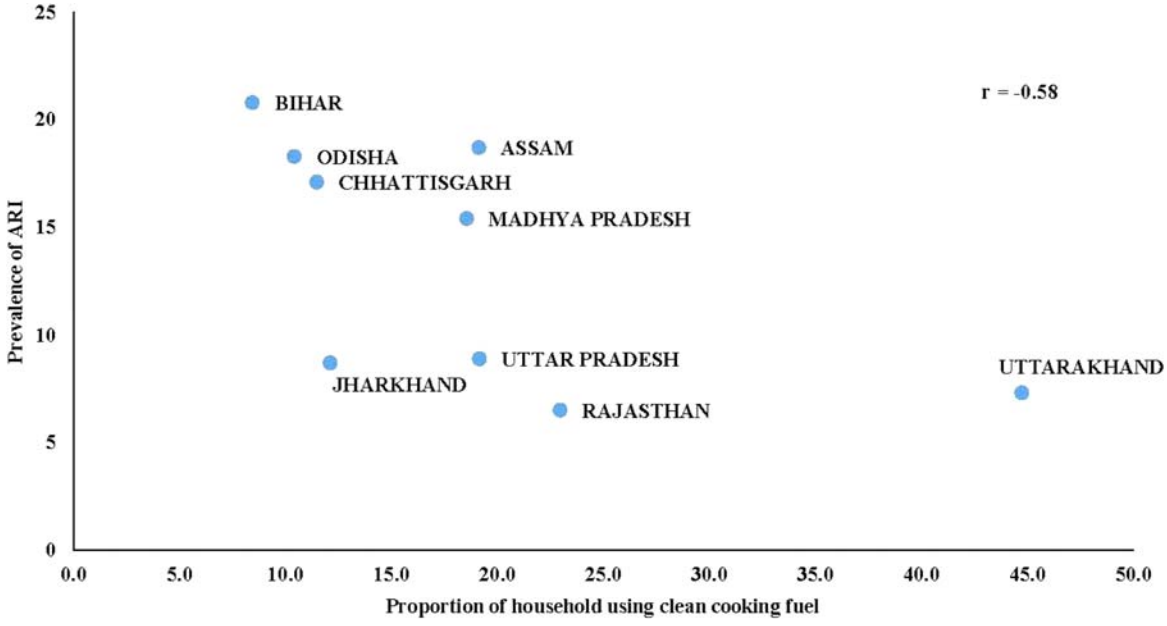

Figure 4 Prevalence of acute respiratory infection (ARI) by proportion of households using clean cooking fuel.

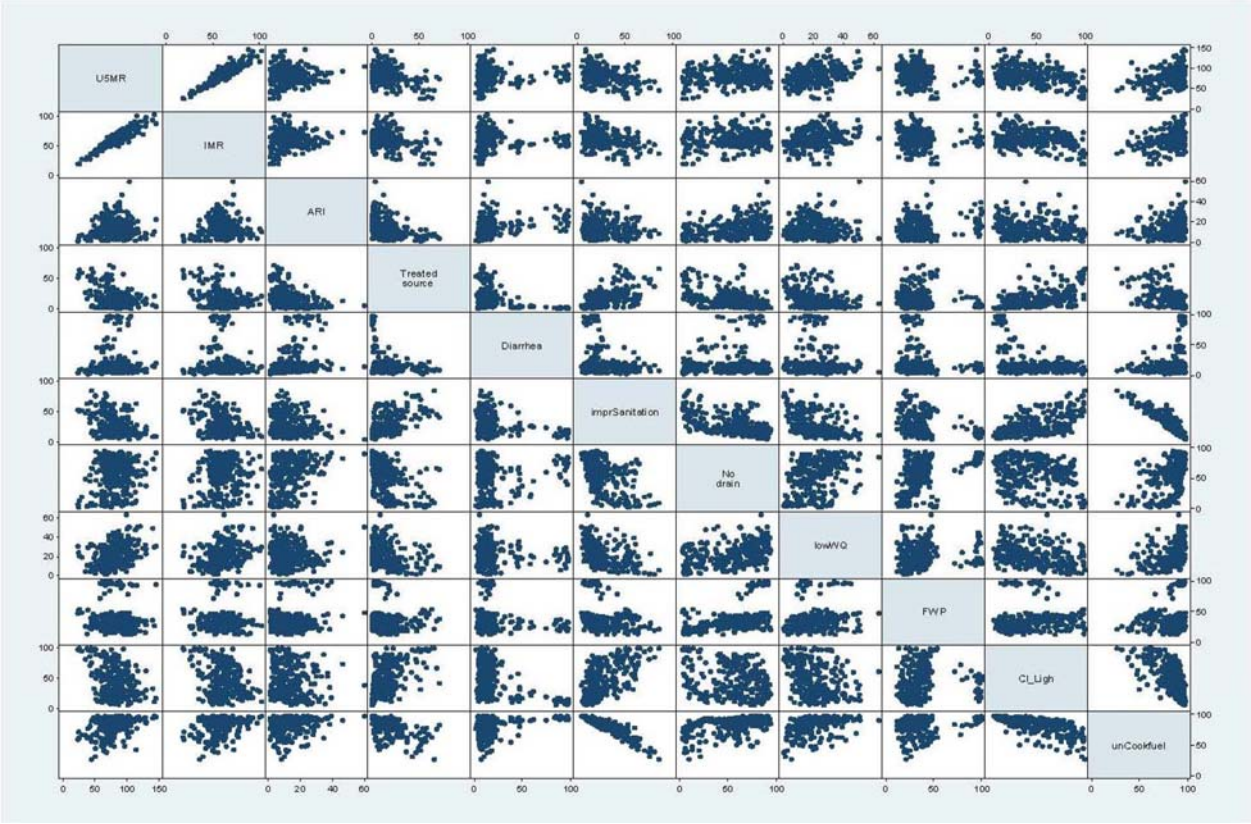

Figure 5 Scatter matrix plot: cross-sectional relationship between IMR/U5MR and selected predictors 2010–2011. ARI, acute respiratory infection; FWP, female work participation; IMR, infant mortality rate; U5MR, under 5 mortality rate.

In addition, the proportion of the household in the lowest 20 percent WQs is also positively associated with the incidence of ARI. Use of unclean fuel can increase the incidence of ARI. After controlling for all the factors, it is found that unclean fuel is the main predictor of ARI among children.

In model 4, results show that improvement of the quality of drinking water and housing sanitation has a significant influence on diarrhoea. Female work participation and proportion of the household in the lowest 20 percent WQs are the other significant covariates of diarrhoea.

DISCUSSION

Plenty of studies have been conducted to assess the relationship between poverty, child malnutrition and geographical characteristics on the one hand, and mortality during infancy and early childhood, on the other.[13 20] However, this is the first study of its kind to examine the role of household amenities on the prevalence of morbidity and mortality during infancy and early childhood. Another novelty of this study is that the unit of analysis is the household at the district level, which is a lower level factor compared with the state/province level. In using

Table 1 Summary statistics of variables used in this study

Variable	Observation	Mean	SD	Minimum	Maximum	CV
IMR	284	60.599	13.972	19.0000	103.0000	23.05 704
U5MR	284	81.423	20.243	24.0000	145.0000	24.86 186
ARI	284	13.264	8.765	1.0000	59.6000	66.07 792
Drinking water from treated source	284	15.839	14.453	0.8505	70.8232	91.24 962
Diarrhoea	284	20.058	22.220	1.9000	97.3000	110.7801
Improved sanitation	284	27.460	16.705	4.8669	84.4413	60.83 396
No drain	284	55.390	25.940	3.0292	94.3212	46.83 162
Lowest 20 percent WQs	284	21.345	11.126	1.0000	63.5000	52.12 289
Female work participation	284	38.475	21.006	12.1665	99.7161	54.59 532
Clean lighting	284	47.260	25.901	6.0930	99.3994	54.80 598
Unclean cooking fuel	284	82.509	13.632	27.0251	97.2055	16.52 157

ARI, acute respiratory infection; CV, coefficient of variation; IMR, infant mortality rate; U5MR, under 5 mortality rate; WQ, wealth quintile.

Table 2 Correlation coefficient of determinants of IMR/U5MR/ARI/diarrhoea

Variables	ARI	Treated sources	Diarrhoea	Improved sanitation	No drain	Bottom WQ	FWP	Clean light	Unclean fuel
ARI	1								
Treated sources	−0.3855	1							
Diarrhoea	0.3455	−0.3256	1						
Improved sanitation	−0.1097	0.5921	−0.2021	1					
No drain	0.3211	−0.5204	0.0431	−0.5834	1				
Lowest 20 percent WQs	−0.0386	−0.2977	−0.0546	−0.4503	0.3192	1			
FWP*	0.1862	−0.1214	−0.1946	−0.2716	0.4761	0.1414	1		
Clean lighting	−0.1318	0.5725	−0.4158	0.6011	−0.2461	−0.3362	0.0666	1	
Unclean fuel	0.1429	−0.5975	0.2598	−0.9227	0.4793	0.4001	0.1914	−0.6615	1

ARI, acute respiratory infection; FWP, female work participation; IMR, infant mortality rate; U5MR, under 5 mortality rate; WQ, wealth quintile.

this unit of analysis, the state level aggregates, which are not always an adequate representative of child health at the household level, can be removed. Findings clearly suggest that most of the districts in the selected states are in a disadvantaged condition. A very small proportion of households in most of these districts have essential amenities such as drinking water from a treated source, clean cooking fuel and improved sanitation. In states such as Odisha, Uttar Pradesh and Bihar, none of the districts make the mentioned amenities available to even half of the households. These are demographically important states since more than one-third of infant deaths (34.19%) occur in these three states in India.[21]

The result of scatter graphs shows that states with a low proportion of households having improved sanitation record a higher IMR. Uttarakhand records the highest proportion of households with improved sanitation and has low IMR. The correlation value (−0.27) also corroborates the argument that there is a negative relationship between improved sanitation and IMR. Households using clean cooking fuel and incidence of ARI is inversely associated in the study. The correlation value (−0.58) also suggests a strong negative association between usage of clean cooking fuel and incidence of ARI among children. At the district level, there is a clear indication that the prevalence of morbidity and mortality during infancy and early childhood is clustered in the disadvantaged districts of the selected states. Districts with a higher proportion of households with basic essential amenities have a low prevalence of IMR, U5MR, ARI and diarrhoea. The OLS analysis shows that improved sanitation has a negative and statistically significant association with U5MR. This indicates that improving sanitation will reduce the chances of U5MR. In the adjusted model, it is observed that drinking water from a treated source and households in a lower wealth quintile are negatively associated with IMR. Further, results have shown that better sanitation practices, availability of drainage facility, improved drinking water and usage of clean cooking fuel will reduce the incidence of ARI and diarrhoea. Results from earlier studies, conducted mainly in African countries, support the findings of this study.[22 23] A study conducted in rural Lesotho and South Africa suggests that improved drinking water supplies can benefit preschool children's health after infancy, but only if it is utilised exclusively for drinking and cooking purposes.[24] Another study conducted in rural India suggests that the prevalence and duration of diarrhoea among children under 5 are significantly lower, on average, for families with piped water than for observationally identical households without piped water; however, the health gains largely bypass children in poor families, particularly when the mother is poorly educated.[25] Although sanitation is not directly linked to all ARIs, a recent study reported that 26% of ARIs among malnourished children in rural Ghana may have

Table 3 Distribution of average infant/child morbidity and mortality rate by district household amenities, 2011

	Improved sanitation				Unclean cooking fuel		Drinking water from treated source	
	IMR		Under 5 mortality		Acute respiratory infection		Diarrhoea	
Districts	Mean	CI	Mean	CI	Mean	CI	Mean	CI
Low	64.1	±5.5	88.4	±8.2	12.0	±3.1	34.2	±13.4
Middle	63.2	±5.0	84.1	±7.0	12.3	±3.4	13.1	±2.9
High	54.4	±5.8	71.7	±8.1	15.5	±4.0	12.8	±2.8

IMR, infant mortality rate.

Table 4 OLS regression estimates: effects of household amenities and selected predictors on IMR, U5MR, ARI and diarrhoea

	Unadjusted estimates			Adjusted estimates		
	Coefficient	**SE**	**CI**	**Coefficient**	**SE**	**CI**
Model 1						
U5MR						
Constant				4.55 869		
ARI	0.00 245	0.00 187	(−0.00 122 to 0.00 613)	0.0028	0.0019	(−0.00 099 to 0.00 487)
Treated source	0.00 074	0.00 105	(−0.00 131 to 0.00 282)	−0.0031*	0.00 183	(−0.00 674 to 0.00 048)
Diarrhoea	0.00 061	0.00 074	(−0.00 084 to 0.00 263)	0.0014**	0.0006	(0.00 089 to 0.0051)
Improved sanitation	−0.00 671***	0.00 089	(−0.00 853 to −0.00 494)	−0.0049***	0.0011	(−0.00 717 to −0.00 263)
No drain	0.00 262***	0.00 061	(0.00 142 to 0.00 383)	0.0002	0.00 077	(−0.00 132 to 0.00 173
low WQ	0.00 815***	0.00 139	(0.00 543 to 0.01 089)	0.00 411***	0.00 162	(0.00 091 to 0.00 728)
FWP	−0.00 052***	0.00 078	(−0.00 211 to 0.00 102)	−0.00 271***	0.0009	(−0.00 449 to −0.00 095)
Number of observation		284		F(7, 276) 12.39***		Adjusted R^2 0.2264
				Shapiro-Wilk test 0.9592		Mean VIF 1.72
Model 2						
IMR						
Constant				4.274 754		
ARI	0.00 272**	0.00 173	(−0.0006 to 0.0062)	0.0032**	0.00 149	(0.00 035 to 0.00 622)
Treated source	−0.00 559***	0.00 103	(−0.00 756 to −0.00 362)	−0.00 291*	0.0017	(−0.0062 to 0.0005)
Diarrhoea	−0.00 291***	0.00 074	(0.00 419 to 0.00 127)	0.00 023***	0.00 058	(−0.00 349 to −0.0012)
Improved sanitation	−0.00 651***	0.0007	(0.0016 to 0.00 105)	−0.00 434***	0.00 107	(−0.00 647 to −0.00 227)
No drain	0.00 223***	0.0005	(0.0011 to 0.0033)	0.00 221	0.00 074	(−0.00 153 to 0.0014)
low WQ	0.00 624***	0.00 132	(0.00 362 to 0.0088)	0.00 272*	0.00 154	(−0.00 038 to 0.00 568)
FWP	0.00 012	0.00 072	(0.0015 to 0.0013)	−0.00 225	0.00 082	(−0.00 381 to −0.0006)
Number of observation		284		F(7, 276) 9.73***		Adjusted R^2 0.2277
				Shapiro-Wilk test 0.9714		Mean VIF 1.72

	Unadjusted estimate				Adjusted estimates			
	Coefficient	**SE**	**Lower bound**	**Upper bound**	**Coefficient**	**SE**	**Lower bound**	**Upper bound**
ARI								
Clean lighting	−0.04461**	0.01997	−0.08393	−0.00529	0.00277	0.02552	−0.04747	0.05302
Uncooked fuel	0.09182	0.03789	0.01726	0.16644	0.16802**	0.09466	−0.0183	0.35439
Treated water	−0.23373***	0.0333	−0.2994	−0.16818	−0.24054***	0.04477	−0.32868	−0.15241
Improved sanitation	−0.05752*	0.0311	−0.1187	0.0035	−0.00292**	0.00107	−0.00647	−0.00227
No drain	0.10841**	0.0191	0.0709	0.146	0.10775	0.02127	0.06588	0.14962
low WQ	0.03043*	0.0469	−0.1227	0.0618	−0.11245**	0.05486	−0.00447	−0.22045
Number of observation	284		F (6,277)	20.83***			Adjusted R^2	0.22771
	Shapiro-Wilk test for normality (probability >z) 0.9596						Mean VIF	3.93
Diarrhoea								
Constant					55.9783			
Treated source	−0.50062***	0.0866	−0.6709	0.3301	−0.51243***	0.10814	−0.72523	−0.29949
Improved sanitation	−0.26873***	0.0776	−0.4215	−0.116	−0.25841***	0.10186	−0.45896	−0.05793
No drain	0.03692	0.0509	−0.0633	0.13723	−0.06652	0.06547	−0.19546	0.06229
low WQ	0.10903*	0.1187	−0.3428	0.1247	0.36895***	0.10256	0.16708	0.57087
FWP	−0.20581***	0.0618	−0.3274	−0.08418	−0.23763***	0.05616	−0.34821	−0.12711
Number of observation	284		F (5, 278)	10.93***			Adjusted R^2	0.19822
	Shapiro-Wilk test for normality (probability >z) 0.94917						Mean VIF	1.67

***p<0.01; **p<0.05; *p<0.1

ARI, acute respiratory infection; FWP, female work participation; IMR, infant mortality rate; OLS, ordinary least square; U5MR, under 5 mortality rate; VLF, variation inflation factor; WQ, wealth quintile.

been due to recent episodes of diarrhoea.[26] Thus, sanitation can be a powerful intervention against ARIs. Like many other studies, this study equally opined that usage of unclean cooking fuel such as cow dung, kerosene and other fossil fuels, increases the incidence of ARI among children.[27 28]

As India is a signatory nation of MDG, it aimed to lower the IMR to 28 by 2015 (MDG 4). Though there has been a decline from 67/1000 in 1992–1993 to 40/1000 in 2014–2015, India is in a race against time to achieve the MDG 4.[21 29] Not only is the decline slow, but there are disparities in the decline across households of India. Some households record a very low level of mortality, whereas others still have substantially high levels of IMR. IMR is a critical determinant to lower the U5MR, since more than half the deaths of children under the age of 5 years occur during the first year of life.[29 30] Diarrhoea and ARI remain more prevalent during infancy and cause many infant deaths in India. The morbidity and mortality indicators selected in this study are interrelated or portray a cause–effect association.

CONCLUSION

Most of the households in the districts of high focus states remain in a disadvantaged position. These states contribute the largest share of infant and child deaths in India. The availability of essential amenities, such as safe drinking water, improved sanitation, clean cooking fuel and drainage facilities at the household level, remains an important determinant of child health. This evidence certainly underscores the need to restrategise our approach to addressing child health issues. So far, rendering of, or making available, basic child health services, has been the sole motive of the government and of policymakers. The National Health Policy (2002) and the NRHM (2005) are serving this purpose in India. Though they have made significant advances in addressing child health issues, they barely touch on the root of the problem. There is a tremendous requirement for health programmes, such as the recently launched *Swatch Bharat Abhiyaan* (2014–2019), to improve sanitary conditions in households in the country. Building toilets, and making safe drinking water, clean cooking fuel and drainage facilities available in households, will prevent a number of adverse child health issues and, perhaps, reduce the burden on the healthcare system in India.

Acknowledgements The authors sincerely acknowledge Shailja Thakur for language editing the paper.

Contributors JG, AKG and AKY contributed in conceptualising the study. AKG and AKY were responsible for the statistical analysis. All authors contributed to the interpretation of the data, and critically revised all versions of the manuscript and approved the final version.

Funding This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Ethics approval This study used secondary data, which are available in the public domain. Thus, there was no need to obtain ethical clearance for this study. Nevertheless, the information was collected with the consent of the concerned samples that are available in the reports (Annual Health Survey and Census of India) and mentioned in the methodology of the study.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

REFERENCES

1. Tripathy P, Nair N, Barnett S, *et al*. Effect of a participatory intervention with women's groups on birth outcomes and maternal depression in Jharkhand and Orissa, India: a cluster-randomized controlled trial. *Lancet* 2010;375:1182–92.
2. UNICEF, WHO. Countdown to 2015: maternal, newborn and child survival. The Executive Summary. 2008.
3. Boerma JT, Bryce J, Kinfu Y, *et al*. Mind the gap: equity and trends in coverage of maternal, newborn, and child health services in 54 Countdown countries. *Lancet* 2008;371:1259–67.
4. Paul VK, Sachdev HS, Mavalankar D, *et al*. Reproductive health, and child health and nutrition in India: meeting the challenge. *Lancet* 2011;377:332–49.
5. Ram U, Jha P, Ram F, *et al*. Neonatal, 1–59 month, and under-5 mortality in 597 Indian districts, 2001 to 2012: estimates from national demographic and mortality surveys. *Lancet Glob Health* 2013:1:e219–26.
6. Pradhan J, Arokiasamy P. Socio-economic inequalities in child survival in India: a decomposition analysis. *Health Policy* 2010;98:114–20.
7. Arokiasamy P, Jain K, Goli S, *et al*. Health inequalities among urban children in India: a comparative assessment of empowered action group (EAG) and south Indian states. *J Biosoc Sci* 2013;45:167–85.
8. Bhutta ZA, Das JK, Walker N, *et al*. Interventions to address deaths from childhood pneumonia and diarrhoea equitably: what works and at what cost? *Lancet* 2013;381:1417–29.
9. Bassani DG, Kumar R, Awasthi S; Million Death Study Collaborators. Causes of neonatal and child mortality in India: nationally representative mortality survey. *Lancet* 2010;376:1853–60.
10. International Institute for Population Sciences (IIPS) and Macro International. *National Family Health Survey (NFHS-3) Report, 2005–06 2007*. Vol I. Mumbai, India: IIPS.
11. Government of India. *A strategic approach to reproductive, maternal, newborn, child and adolescent health (RMNCH+A) in India. For healthy Mother and Child MoHFW*. Government of India, 2013.
12. NIMS, ICMR and UNICEF. *Infant and child mortality in India: levels, trends and determinants, National Institute of Medical Statistics (NIMS), Indian Council of Medical Research (ICMR), and UNICEF India Country Office*. New Delhi, India, 2012.
13. Kumar C, Prashant KS, Rajesh KR. Under-five mortality in high focus states in India: a district level geospatial analysis. *PLoS ONE* 2012;7:e37515.
14. Husain Z. Health of the national rural health mission. *Econ Pol Wkly* 2011;46:53–60.
15. Programme evaluation organization. *Evaluation study of National Rural Health Mission in 7 states planning commission*. Government of India, 2011.
16. Registrar General of India and Census Commissioner Census of India –2011: Provisional Population Totals Series 2011 1. New Delhi: Ministry of Home Affairs, Government of India.
17. Chandramouli C. *Census of India 2011—a story of innovations*. New Delhi: Press Information Bureau Government of India, 2011.
18. Goli S, Jaleel AC. What is the cause of the decline in maternal mortality in India? Evidence from time series and cross-sectional analyses. *J Biosoc Sci* 2014;46:351–65.
19. Bhattacharya PC, Cornilius C. Inequalities in child mortality in India. *Asian Popul Stud* 2011;7:243–61.
20. Singh A, Pathak PK, Chauhan RK, *et al*. Infant and child mortality in India in the last two decades: a geospatial analysis. *PLoS ONE* 2011;6:e26856.
21. Registrar General of India SRS Bulletin. Sample Registration System 2014; September, 49 (1).
22. Fayehun OA. *Household environmental health hazards and child survival in Sub-Saharan Africa*. DHS Working Papers No. 74. Calverton, Maryland, USA: ICF Macro, 2010.

23. Argeseanu S. Risks, amenities, and child mortality in rural. South Africa. *African Popul Stud* 2004;19:13–33.
24. Esrey SA, Habicht JP, Latham MC, *et al*. Drinking water source, diarrheal morbidity, and child growth in villages with both traditional and improved water supplies in rural Lesotho, southern Africa. *Am J Public Health* 1988;78:1451–5.
25. Jalan J, Martin R. Does piped water reduce diarrhea for children in rural India? *J Econ* 2003;112.1:153–73.
26. Schmidt WP, Cairncross S, Barreto ML, *et al*. Recent diarrhoeal illness and risk of lower respiratory infections in children under the age of 5 years. *Int J Epidemiol* 2009;38:766–72.
27. Kilabuko JH, Nakai S. Effects of cooking fuels on acute respiratory infections in children in Tanzania. *Int J Environ Res Public Health* 2007;4:283–8.
28. Isara AR, Aigbokhaode AQ. Household cooking fuel use among residents of a sub-urban community in Nigeria: implications for indoor air pollution. *Eurasian J Med* 2014;46:203–8.
29. Reddy H, Pradhan MR, Ghosh R, *et al*. India's progress towards the Millennium Development Goals 4 and 5 on infant and maternal mortality. *WHO South East Asia J Public Health* 2012;1:279–89.
30. Black RE, Saul SM, Jennifer B. Where and why are 10 million children dying every year? *Lancet* 2003;361.9376:2226–34.