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IMPACT OF WATER AND SANITATION ON SELECTED WATER BORNE DISEASES IN INDIA

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Abstract

One of the Millennium Development Goals is to provide improved sanitation facilities along with availability of potable water; which are indeed the two basic needs for human survival. However, despite significant investments over the last 20 years, India still faces the most daunting sanitation challenge and its sanitation is rated as the second worst in the world after China. At present only 28 per cent of people in rural areas have access to toilets leading to severe burden of preventable diseases.

With a view to assessing health impact of water borne diseases this study provides first an assessment of direct impact of water and sanitation facilities on incidence of selected diseases in major Indian states. This is followed by an estimation of input efficiency estimates for 28 Indian States. This is done using data envelopment analysis. It is suggested by our results that there is a positive impact of reducing the incidence of selected diseases by the state investments on water and sanitation facilities. However, the differentials impact across states of these inputs in reducing the incidence of four water borne diseases, namely, acute diarrhoea, enteric fever, viral hepatitis and malaria could be minimized to a certain extent if these inputs are targeted more effectively and some changes are made in other funding sources like NRHM.

Keywords: *Health, water borne diseases, states, efficiency*
JEL Codes: *Q 25, Q 28, H 51, C 14*

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INTRODUCTION

The exposure to an unhygienic environment and the excessive focus on curative medical care has mostly undermined the much more cost-effective and efficient option of preventive public health investments that can stem the spread of infectious diseases and improve nutritional outcomes in the country. A WHO study had estimated that costs due to poor sanitation facilities were to the tune of more than 6 percent of India's gross domestic product in 2006 (WHO, 2012). There is a growing research evidence that shows how eradicating open defecation and improving sanitation can improve health outcomes greatly, and especially among children it can lead to reduced incidence of illnesses such as diarrhoea. A recent study, for instance, shows that the provision of safe water and better sewage facilities reduced infant mortality significantly in the greater Boston area between 1880 and 1915 (Alsan and Goldin, 2015). Alsan and Goldin use their findings to underline the importance of providing proper sewage facilities in a rapidly urbanizing Third World.

In today's world, the importance of sewage facilities extends beyond curbing infant mortality. The use of untreated sewage water for irrigation and the contamination of water bodies and contiguous areas is fast emerging as a health and environmental hazard in several countries, including India. Such findings corroborate earlier research that underlines the importance of public health interventions such as sanitation and waste management.

A lot of economic research has focused on evolving policies that can address the challenges to effective provision of public services in the health sector. The 2015 World Development Report entitled Mind, Society and Behaviour analyses such studies in the health sector (World Bank, 2015). The discussion includes providing appropriate incentives for both service providers and seekers to pursue desired behaviour as well as recognizing the stigma certain communities or diseases might face.

Scientific evidence emphasizes that some of the common pathogens capable of sickening humans and animals caused by contamination of water through sewage and which survive in bodies of water for days or weeks can cause a number of diseases (GESAMP, 2001). In general, a classification of water related diseases is provided in terms of Water-borne, Water-washed, Water-based and water-related vectors. The diseases cited under these categories may include Diarrhea, Dysenteries, Typhoid fever, Scabies, Trachoma (Water-borne and Water-washed), Schistosomiasis, Guinea worm (Water-based) and Dengue, Malaria and Trypanosomiasis (Water-related insect vectors). The incidences of these cases vary considerably across Indian states with differing range.

Since 1986, according to official statistics, India has spent over $3 billion on constructing toilets across the country (Sreevatsan, 2014). Despite such massive investments, India continues to have the largest number of people who defecate in the open. Even poorer countries in the neighborhood, such as Bangladesh and Nepal, have improved sanitation coverage faster and surpassed India in the last two decades. Over the next five years under the Swachh Bharat mission the government is now planning to spend an additional $31 billion (Rs.1.9 lakh crore). Further in terms of per capita expenditure by central and state governments on these items in constant prices, there has been an increase from Rs. 33 (in 2004-05) to Rs. 82 (in 2010-2011) (Choudhury and Amar Nath, 2012). In the same duration the ratio of central and state governments in the total expenditure on water sanitation has changed from 26:74 to 34:66. But to ensure that such massive investment really bears tangible results some quantification of the health impact of government investment in water and sanitation might be a worthwhile exercise. Objective of this paper is to attempt an assessment of the impact of water and sanitation facilities on selected water borne diseases in India.

INCIDENCE OF WATER BORNE DISEASES IN MAJOR STATES IN INDIA

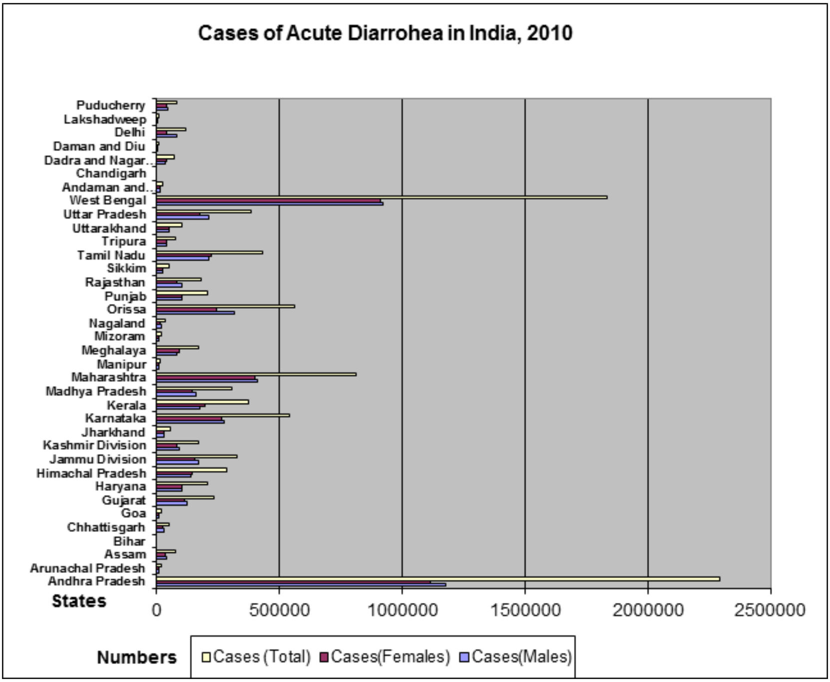
In India, the total number of cases of the water borne diseases reported is presented in Table 1 which indicates highest number of cases for acute diarrhea followed by enteric fever, malaria and viral hepatitis. However, in terms of total number of deaths the highest varies from acute diarrhea to viral hepatitis followed by enteric fever and malaria (Table 1). Focusing on 28 major Indian states, the incidence of these diseases indicates regional variations caused possibly by geographical locations and other climatic factors. This could be observed, for instance from Figure 1, which provides the latest published figures for the year 2010 for Acute diarrhoea. Likewise incidence of enteric, viral hepatitis and malaria is presented in Figures 2-4. It is observed that Andhra Pradesh has the maximum number of reported case in three of these water borne diseases namely, acute diarrhoea, enteric fever and viral hepatitis (Figures 1 to 3) and Orissa has the maximum reported cases for Malaria (Figure 4).

Table 1: Number of Cases and Deaths Due to Five Major Water Borne Diseases in India

ALL INDIA	Male		Female		Total	
2011 (or latest available figures)	Cases	Deaths	Cases	Deaths	Cases	Deaths
Acute Diarrhoea	5201803	838	4911042	550	10112845	1388
Viral Hepatitis	55398	362	39004	158	94402	520
Enteric fever	798615	260	679084	168	1477699	428
Malaria					733049	280

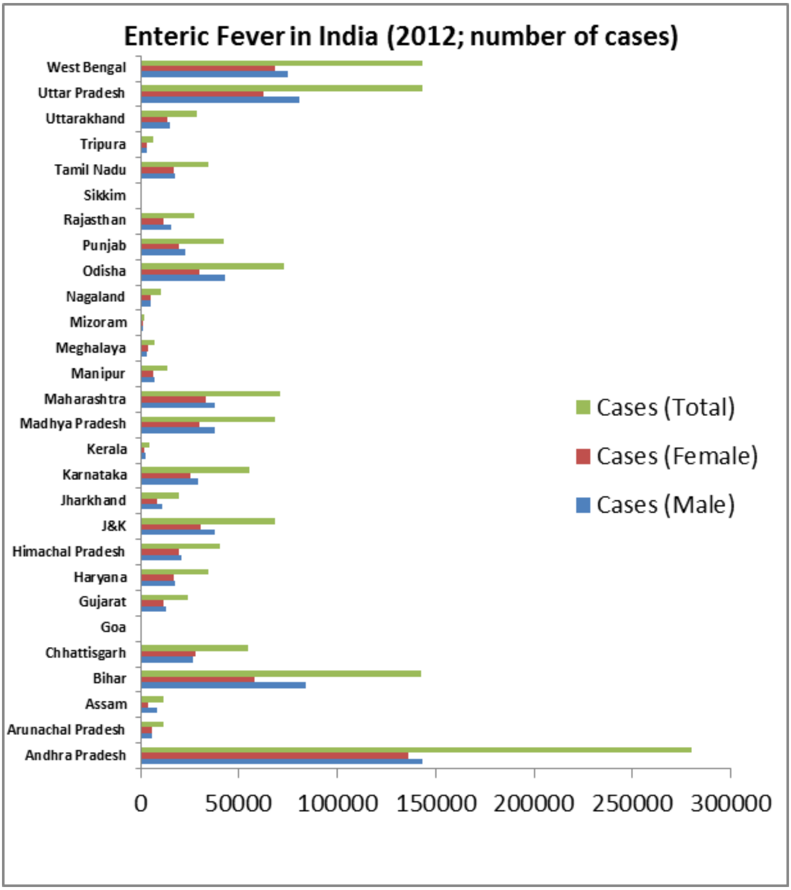
Source: Indiastat.com; primary source answers in Parliament.

Figure 1: Acute Diarrhea Among Indian States



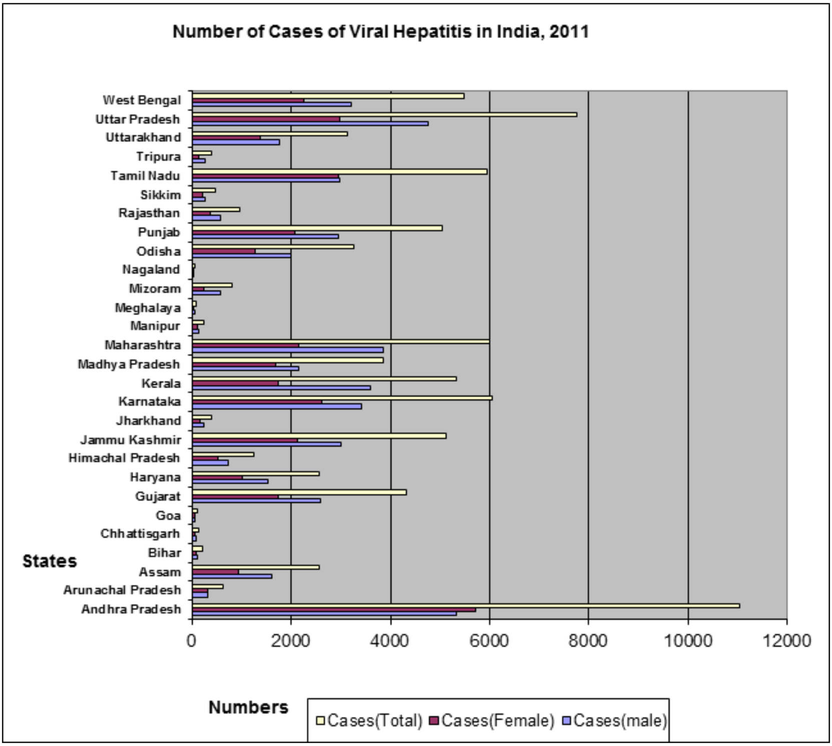
Source: Estimated.

Figure 2: Enteric Fever Among Indian States



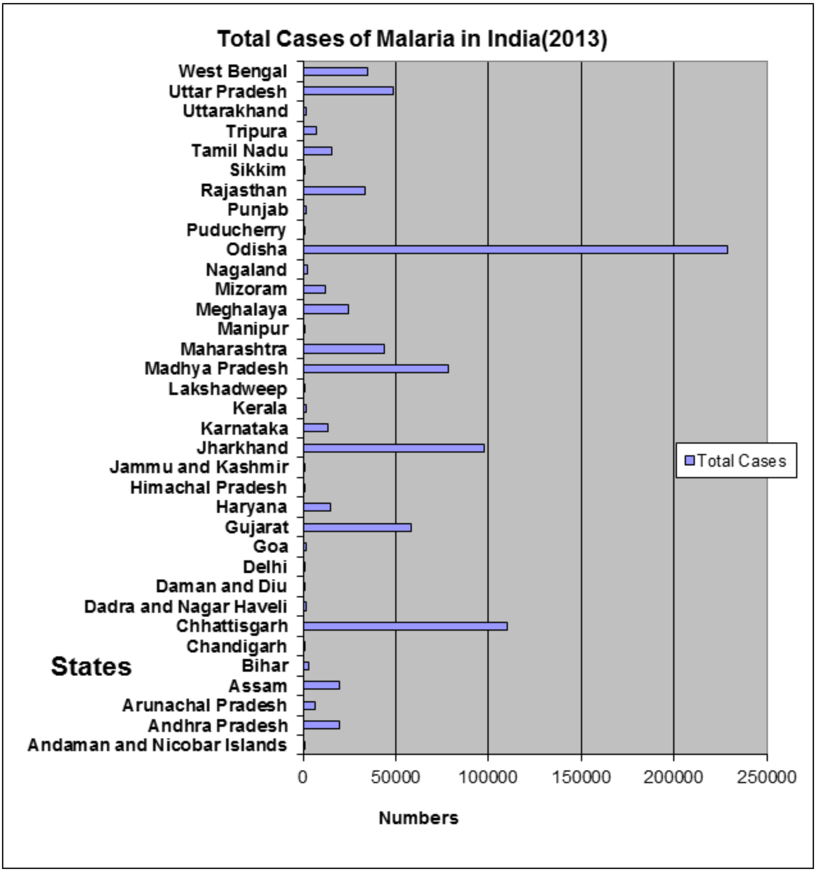
Source: Estimated.

Figure 3: Viral Hepatitis Among Indian States



Source: Estimated.

Figure 4: Malaria Among Indian States



Source: Estimated.

IMPACT OF WATER AND SANITATION FACILITIES ON WATER BORNE DISEASES

The measurement of health impact from the availability of water supply and sanitation facilities (WSS) has been attempted by considering either the incidence of diseases or infant mortality rate as dependent variable. There have been a number of exhaustive reviews which cover a large no. of studies to analyze the impact of WSS facilities or policies. For instance, beginning with review of 144 studies by Esrey *et. al.* (1985) relating to water-sanitation and diseases like ascariasis, diarrhoea, drancunculiasis, hookworm infection, scistosomiasis and trachoma which indicated that WSS led to reduction in morbidity ranging from 4-78 percent for different diseases; there are also studies which opined that improved WSS facilities are not efficacious in improving health status and not particularly cost-effective (Walsh and Warren, 1979). An another review of 67 studies from 28 countries found that WSS investments can reduce diarrhoea morbidity and mortality rates by a median of 22 percent and 21 percent, respectively (Esrey, S. *et. al.*, 1985). In fact some researchers have also pointed out that the results of studies reviewed were also influenced by the methodologies adopted, inadequate health indicators and lack of control for confounding variables including selective primary health care and other health facilities (Blum and Feachem, 1983).

There have been case-control studies in some countries. Such types of studies include countries namely, Lesotho (Daniels, D. *et. al.* 1990), Malawi (Young and Briscoe, 1988), and Philippines (Baltazar, J. *et. al.*, 1988). These studies have put a reduction owing to WSS investments between 20- 24 percent in the incidence of diarrhoea. A study by Guilkey and Riphahn (1998), for instance using a longitudinal data from metropolitan Cebu-Philippines from 1983 to 1986 for child mortality up to 2 years indicated that child mortality varies significantly between birth weight and nutritional status. Another study for Bangladesh and Philippines analyzing the impact of water quality, sanitation and socioeconomic factors on child health pointed out no significant effect between water supply and source of drinking water, sanitation and child health (Lee, Rosenzweig and Pitt, 1997). In the Malaysian context using stratified partial likelihood estimation, similar conclusions were drawn (Ridder and Tunali, 1999). Whereas WHO (2000) based on primary survey using a logit regression model indeed indicated a negative relationship between arsenicosis and household income. In a survey in Argentina during the period of 1990-1999, it was found that the privatization of water services is associated with 33 percent reduction in the mortality rate, which amounts to a 5.3 percent reduction of the baseline rate (Galiani *et. al.,* 2005).

Studies in the Indian context indicate a significant impact of water borne diseases on child mortality. An estimated 105 million children under 5 years die each year due to water borne diseases resulting in a loss of 200 million man-hours a day every year(or Rs.36, 000-366 billion crores) (Shanmuganandan, 1999). Impact of water contamination in increasing water related diseases was also established by a survey of three villages Gudimallur, Devathanam, Vannivedu of Tamilnadu (Sankar, 2001). Another study in rural Andhra Pradesh indicated that up to 15 million people are using water obtained from unsafe source which may have identifiable health effects (Hughes *et. al.*, 2001). A primary survey for the period 1993-94 found that the overall prevalence of diarrhoea is 10.1 with an average of .33 days of illness and mean expenditure of 0.74 rupees per episode of diarrhoea (Jalan and Ravallion, 2003). Access to piped water led to a significant reduction (21 percent) in diarrhoea prevalence and duration. Using factoral analysis another study also found significant impact of water and sanitation facilities in rural and urban sectors on Infant Mortality Rate (IMR), Crude Death Rate (CDR) and incidence of different diseases (Purohit and Siddiqui, 2004). In rural Uttarakhand with a primary survey of 1530 households in 2004-05, Murugesan, Dayal and Chugh, 2008 indicated that latrine availability affected episodes of diarrhea negatively, and the availability of water, education, poverty and the Swajal programme had a positive effect on latrine availability and use. In Dahod District of Gujarat it was found that the toilets significantly reduced not only the cost of medical treatments but also the loss of wages induced by sanitation-related diseases (Agoramoorthy and Hsu, 2009). A study in Chromepet and Pallavaram township of Tamil Nadu using primary data indicated that drinking water quality and sanitation significantly affect the health of households (Srinivasulu and Haripriya, 2004). Another study, by contrast, in the districts of Murshidabad and Bankura in West Bengal indicated that by providing only toilets in the individual houses, the disease burden may not reduce substantially. It should also be accompanied with improvements in drainage condition, general sanitation, personal hygiene and food sanitation to minimize the disease burden among the villagers (Sulabh Int. Serv. Org, 2007).

From the above review of studies we hypothesize that there is a link between health status and water supply and sanitation (WSS) which works directly through its impact via transmission or incidence of water borne diseases. There also exists an indirect impact of WSS which impinges on efficiency of health facilities and has its impact in the presence of differentials in socio-economic variables. In line with some of the studies reviewed above, we have also chosen incidence of diseases (as indicated by number of cases of a particular disease reported) as a dependent variable to estimate direct impact of water and sanitation facilities.

This study is based on secondary data. To estimate direct impact of WSS, information is collected from National sample Survey 69th round (GoI, 2013). Main variables used to study direct impact are number of cases of different diseases and variables relating to availability of water and sanitation in different states and other related variables.

In order to estimate the direct impact of WSS, we utilized regression analysis which gave the impact coefficients to indicate the importance of *aprioi* causal factors on the incidence of a particular disease which is denoted by no. of cases of the disease (or number of deaths due to a disease) taken as the dependent variable. The 28 Indian states for which data for this analysis have been used include Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Punjab, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttarakhand, Uttar Pradesh and West Bengal. We used this analysis for four major diseases which are associated with WSS and continue to prevail in most of the states. These include acute diarrhoea, viral hepatitis, enteric fever and malaria. Among the explanatory variables we included sets of variables representing drinking water facilities and sanitation amenities. Thus in our regressions main explanatory variables were, namely, improved source of drinking water, households treating drinking water by any method during 2012, sufficient drinking water, households without latrine facility, having exclusive use of latrine and households having access to improved source of latrine throughout the year. All these variables were used for rural urban areas separately. The results of our analysis are presented in the following Tables 2 - 5.

As presented in Table 2, the water variable, namely, water treated by any method by households is significant both in male and female deaths by acute diarrhoea. The value of coefficient is higher for water treated in urban areas which varies between -1.043 (for total cases) compared to -1.10 (for males and females separately). Water treated in rural areas has also a statistically significant coefficient the value of which varies between -.55(for total case) to -.575 (for male cases). These coefficients are relating to double log specification and thus denote elasticity of disease incidence with respect to improved water facilities. It indicates that precautionary measures prior to using water for drinking purposes are helping in reducing the incidence of acute diarrhoea. Unlike acute diarrhoea, however, no toilets variable for rural and urban areas separately emerge as significant for cases of viral hepatitis and the coefficient is .413 and .327 indicating that absence of toilet facilities or open defecation increase chances of viral hepatitis (Table 3). The results for enteric fever cases significant only for males depict the negative impact of water treated and improved sanitation facilities both in rural and urban areas. The coefficient for water treated and improved sanitation for rural areas is -.708 and -1.042 and the respective values for urban areas remain as -1.514 and -6.50. Thus a more prominent impact of water sanitation variables for enteric fever is observed for urban areas (Table 4). Even the desirable negative impact on enteric fever is observed separately by statistically significant coefficients of exclusive latrine facility in rural and urban areas (columns 1 and 2; Table 4). Pertaining to Malaria cases, the desirable impact is observed for exclusive latrine facility and improved sanitation facility separately both in rural and urban areas (Table 5). The impact of no toilets (or open defecation) is observed by positive and significant coefficients of this variable in rural and urban areas (column1 and 2; Table 5). Thus overall our results indicate that water sanitation facilities have helped to provide preventive inputs to reduce the incidence of three of the diseases namely, acute diarrhoea, enteric fever and malaria.

Table 2: Regression Results: Dependent Variable: Acute Diarrhoea Deaths

Dependent Variable : Acute Diarrhoea deaths						
Total Cases	Male Cases (D)	Male Cases(D)	Female Cases(D)	Female Cases (D)	Total cases (D)	Total cases (D)
Explanatory Variable\Statistic↓						
Intercept	5.57* (-3.23)	9.23** (-2.35)	5.23* (-3.34)	9.01** (-2.5)	5.89** (-3.4)	9.36** (-2.35)
Water treated Rural	-.575*** (-1.98)		-0.57** (-2.12)		-.55*** (-1.86)	
Water treated Urban		-1.10*** (-1.79)		-1.10*** (-1.96)		-1.043 (-1.67)
No toilet Rural						
No toilet Urban						
Exclusive Latrine facility Rural						
Exclusive Latrine facility Urban						
Improved sanitation Facility Rural						
Improved sanitation Facility Urban						
R_2	0.104	0.081	0.126	0.105	0.09	0.067
F Statistic and DF	3.9 and 24	3.22 n24	4.48 n25	3.83 n25	3.48 n24	2.79 n24

Source: Estimated.

Table 3: Regression Results: Dependent Variable: Viral Hepatitis Cases

Dependent Variable: Viral Hepatitis		
	Total cases	**Total cases**
Intercept	5.10* (6.94)	6.17* (12.13)
Water treated Rural		
Water treated Urban		
No toilet Rural	.413* (3.04)	
No toilet Urban		.327** (2.38)
Exclusive Latrine facility Rural		
Exclusive Latrine facility Urban		
Improved sanitation Facility Rural		
Improved sanitation Facility Urban		
R_2	0.23	0.14
F Statistic and DF	9.25n26	5.65n26

Source: Estimated.

Table 4: Regression Results: Dependent Variable: Enteric Fever Cases

Total Cases Enteric Fever	**Male Cases**	**Male Cases**	**Male Cases**	**Male Cases**
Intercept	-17.61* (-3.72)	-34.39* (-3.14)	63.33* -3.41	19.91* -8.74
Water treated Rural				-.708* (-3.13)
Water treated Urban			-1.514* (-3.03)	
Exclusive Latrine facility Rural	-1.365* (-3.72)			
Exclusive Latrine facility Urban		-3.85** (-2.28)		
Improved sanitation Facility Rural				-1.042** (-2.79)
Improved sanitation Facility Urban			-6.50** (-2.25)	
R_2	0.32	0.13	0.44	0.4660
F Statistic and DF	13.8n26	5.21n26	11.94n26	12.78n 28

Source: Estimated.

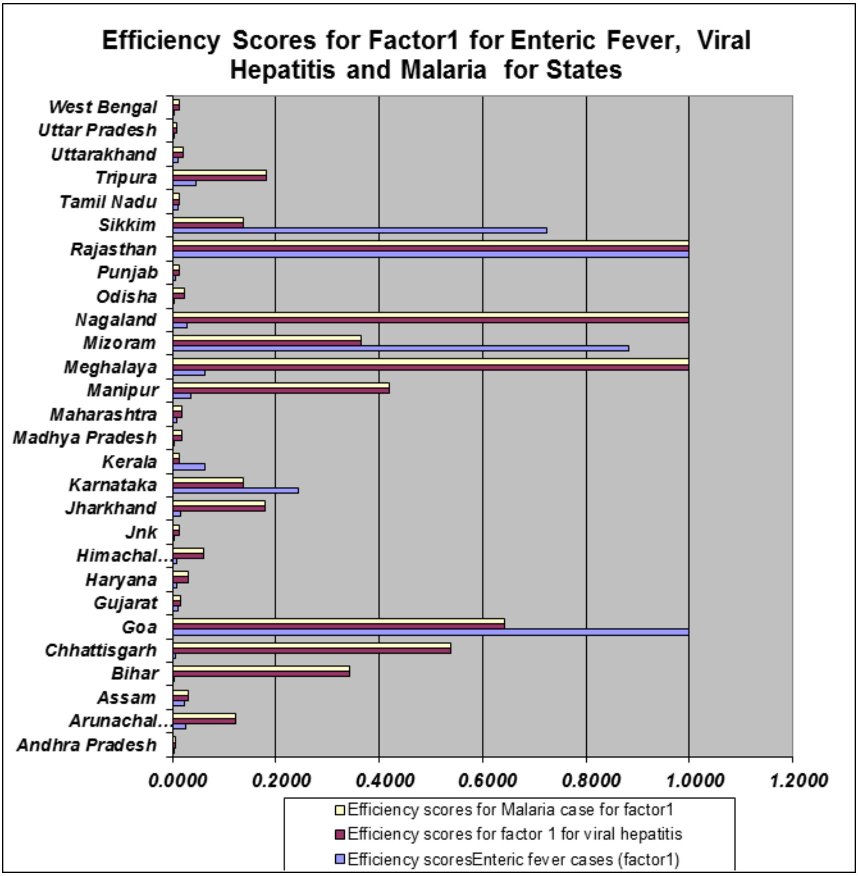
Table 5: Regression Results: Dependent Variable: Malaria Cases

Dependent Variable: Malaria						
Total Cases	Total Cases	Total Cases	Total Cases	Total Cases	Total Cases	Total Cases
Explanatory Variable\Statistic						
Intercept	6.03* (6.4)	7.70* (11.46)	21.85* (-7.25)	20.51* (-7.54)	21.85* (-7.25)	71.86* (-2.49)
Water treated Rural						
Water treated Urban						
No toilet Rural	.625* (3.59)					
No toilet Urban		.48** (2.64)				
Exclusive Latrine facility Rural				-1.877* (-4.19)		
Exclusive Latrine facility Urban						-9.20** (-2.17)
Improved sanitation Facility Rural			-2.052* (-4.22)			
Improved sanitation Facility Urban					-2.05* (-4.22)	
R_2	0.3	0.18	0.38	0.38	0.38	0.15
F Statistic and DF	12.87n26	6.96n26	17.81n26	17.55n26	17.81n26	4.72n26

Source: Estimated; Note: Figures in the parentheses denote "t" ratios. Level of significance: *=5 percent, **=10 percent.

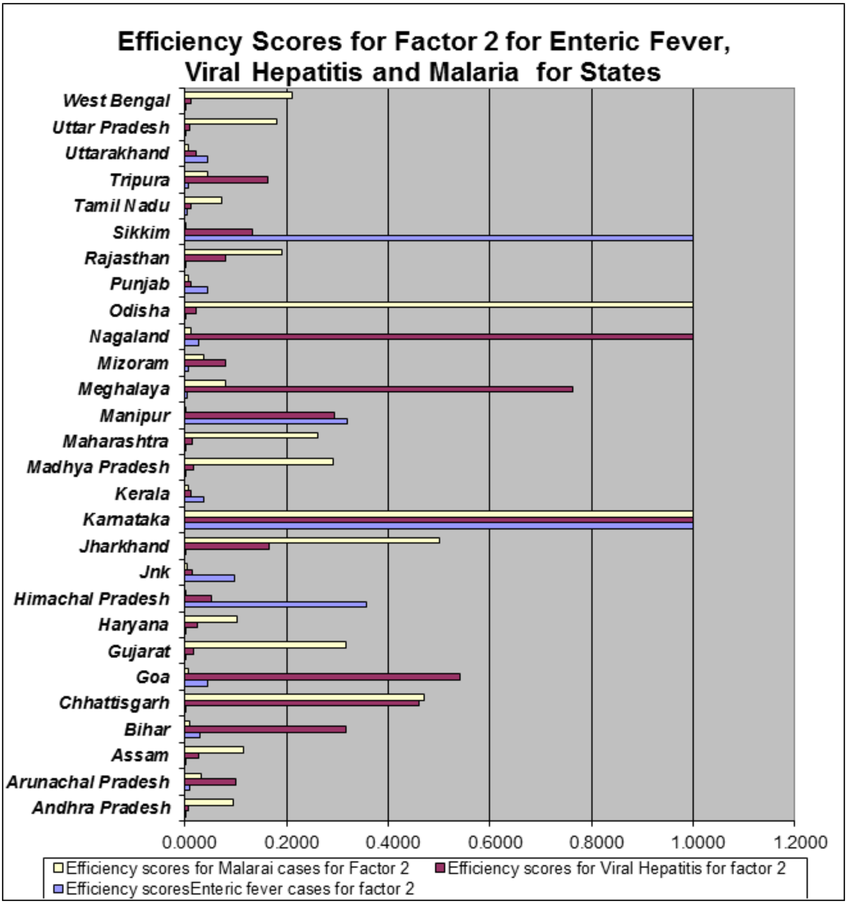
However, the inputs use efficiency of water sanitation variables differ considerably across states. This may become thus additional variable other than local climatic conditions and epidemiological factors which lead to differentials in incidence of these diseases. In order to depict these differentials in input use efficiency of water sanitation variables we computed factor scores by taking a sub-set of above variables which were observed with low correlations. The correlation matrix and the principal components derived from these variables are presented in Annexure Tables A1 and A2. Using these principal components for which Eigen values were greater than one, we selected two factors and the factor scores relating to these two factors namely, number of households who constructed independent toilets until 2011-12 (factor 1) and exclusive use of latrines (factor 2) were used to estimate output oriented efficiency values using data envelopment analysis. These efficiency estimates for factor 1 and 2 for three diseases are presented in Figures 5-6 below. It could be observed from Figure 5, for instance, that efficiency scores pertaining to enteric fever for factor 1 are optimal for Goa and Rajasthan. Likewise efficiency scores for factor 1 for viral hepatitis as well as malaria are optimal for Rajasthan, Meghalaya and Nagaland (Figure 5). Similarly in regard to factor 2, the efficient input utilization is observed for Karnataka and Sikkim (for enteric fever), Karnataka and Nagaland (for viral hepatitis) and Orissa and Karnataka (for malaria) (Figure 6).

Figure 5: Efficiency scores for factor 1 for Indian States



Source: Estimated.

Figure 6: Efficiency Scores for Factor 2 for Indian States



Source: Estimated.

Besides the variations in efficiency of input usage in the states, there is also evidence from empirical studies that some funds for water and sanitation which also flow under National Rural Health Mission (NRHM) under health sector funding have been partly not fully utilized by the states (Hooda, 2013). Due to the clause that state governments needs to increase their own spending at a specified rate in tandem with the increased central funding many states owing to the inadequate absorptive capacity of state governments have not been able to increase optimally the expenditure on this component.

CONCLUSIONS

Our results indicate that the impact of government policy in terms of increased budgetary expenditure across 28 states has been positive in controlling the incidence of three water borne diseases, namely, acute diarrhoea, enteric fever and malaria. However, besides state specific climatic and epidemiological factors, the efficiency of the use of these inputs has considerable variations which partly also influence the outcome of controlling the incidence of these diseases. There is also an influence of differential utilization of funds flowing under NRHM across states due to the clause of increase in state own expenditure along with central funding. However, our results are indicative and the underlying assumptions of reliability of available data and our analytical techniques also remain as limitations.

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ANNEXURE

Table A1: Correlation Matrix for Principal Components

Households with constructed latrines upto 2011-12	1				
Exclusive use of latrine facilities rural	-0.4953	1			
water treated by any method rural	-0.3393	0.3491	1		
improved drinking water rural	0.2285	-0.1755	-0.3758	1	
sufficient drinking water throughout the year rural	0.1235	-0.1924	-0.3674	-0.0067	1

Source: Estimated.

Table A2: Principal Components

Component	Eigen value	difference	Proportion	cumulative
Component 1	2.11126	1.08987	0.4223	0.4223
Component 2	1.0214	0.111372	0.2043	0.6265
Component 3	0.910026	0.412739	0.182	0.8085
Component 4	0.497287	0.037261	0.0995	0.908
Component 5	0.460026	.	0.092	1

Source: Estimated.

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