

Linkage between Water, Sanitation and Health Outcomes: An Empirical Analysis of Indian States

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Abstract- Access to drinking water and sanitation is both a human rights issue and a key development challenge that has profound health implications. This study probes into the current scenario access to safe drinking water and sanitation in India, analyzes the progress made in last decades, and also evaluates its impact on infant mortality rate and child mortality rate. Applying Principal Component Analysis (PCA), the study aims to construct a comprehensive measure of sanitation. The index of sanitation so derived has been then used in regression analysis- to investigate its impact on health, and also in cluster analysis- to prepare typology of sanitation and health.

Index Terms- Child mortality rate, Infant mortality rate, Principal Component Analysis (PCA), Sanitation

I. INTRODUCTION

If water is life, sanitation is surely “a way of life”. Adequate sanitation, together with good hygiene and safe water, are fundamental to good health and to social and economic development. Access to basic sanitation is a crucial human development goal in its own right, but sanitation is also a means to far wider human development ends (UNDP 2006). “Not having access” to water and sanitation is a polite euphemism for a form of deprivation that threatens life, destroys opportunity and undermines human dignity. The global importance of water, sanitation and hygiene for development, poverty reduction and health is reflected in the United Nation’s Millennium Declaration, in particular its seventh Millennium Development Goal (MDG): ensuring environmental sustainability by reducing the proportion of people without sustainable access to safe drinking water and basic sanitation by half by the year 2015 (United Nations 2000) and sixth Sustainable Development Goal (SDG): ensuring availability and sustainable management of water and sanitation for all. Recent decade has witnessed a proliferation in the research studies on various aspects of sanitation viz. coverage, impacts, constraints, governance etc. reflecting the increasing realization of the importance of sanitation as a fundamental means of preventing diseases and elevating quality of life. However, despite increasing political willingness and advocacy, sanitation remains one of the most intractable challenges for developing countries including India.

The UNICEF and WHO (2015) reports that the world had already met the MDG water target in 2010, five years ahead of schedule, but global MDG target for sanitation has been missed by 700 million people. Since 1990 well over 2 billion people have gained access to improved source of drinking water and 116 countries have met the Millennium Development Goal (MDG)

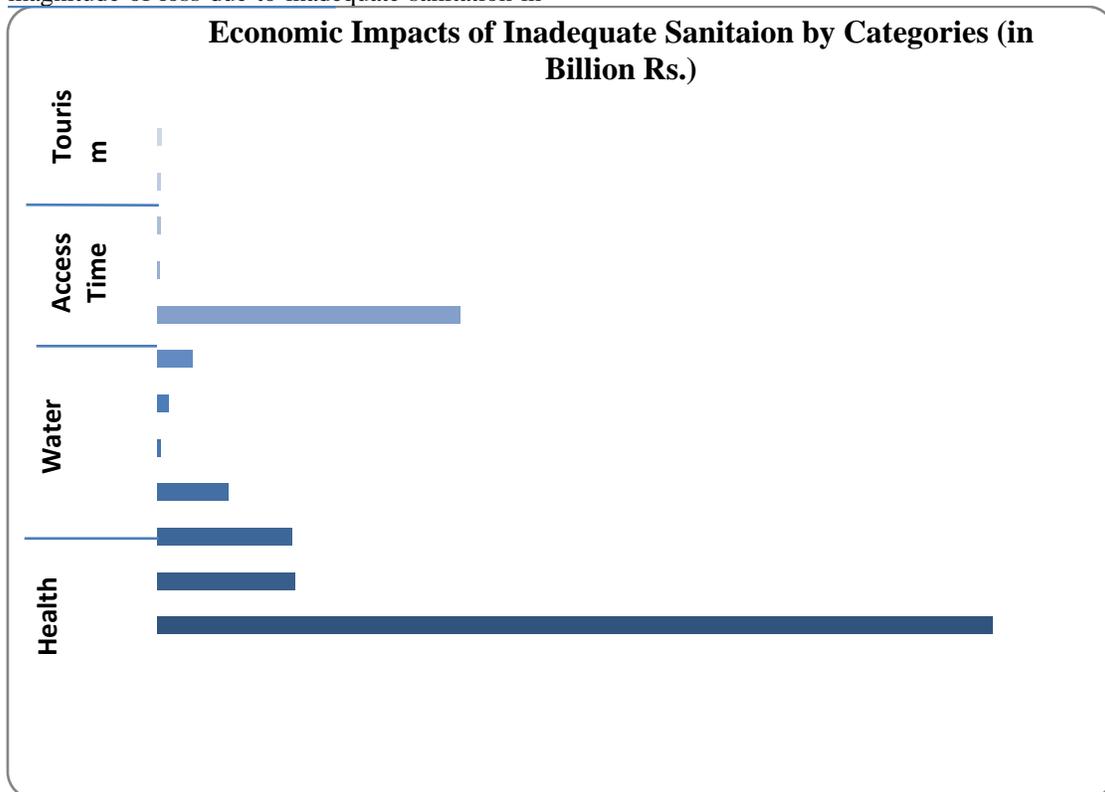
target for water. Almost 2 billion people have gained access to improved sanitation and 77 countries have met the MDG target. Open defecation decreased from 24 per cent to 14 per cent globally. Success of Ethiopia, Cambodia and Nepal stand out as examples. But stark disparities across regions, between rural and urban, and between rich and poor countries demand more committed effort. In 2015, 2.4 billion people in the world do not have access to basic sanitation, whereas 663 million people lack access to safe drinking water. UNICEF and WHO (2012) puts forth some important and interesting facts about India:

- (1) While deprivation is unequally distributed across regions of India, the facts of the water and sanitation crisis speak for themselves. A considerable proportion of global population who have gained access to drinking water since 1990, live in India (522 million). But India is still home to 97 million people without access to improved water supply. This represents about 12.58 per cent of global population that remains unserved.
- (2) Since 1990, 251 million people have gained access to improved sanitation in India. 11 countries make up more than three quarter (76%) of the global population without improved sanitation facilities. One third of the 2.4 billion people without improved sanitation live in India (814 million).
- (3) Nearly 60 per cent of those practicing open defecation live in India (626 million people).

Poor sanitation, hygiene and water are responsible for about 50 percent of the consequences of childhood and maternal underweight, primarily through the synergy between diarrheal diseases and under nutrition, whereby exposure to one increases vulnerability to the other (Hutton and Haller 2004, Blossner 2005, World Bank 2008). WHO (2008) estimates that globally eighty eight per cent of diarrheas are attributable to unsafe water, inadequate sanitation or insufficient hygiene. It also states that almost one tenth of global disease burden could be prevented by improving water supply, sanitation, hygiene and management of water resources. Another estimate reports that water, sanitation and hygiene are responsible for four percent of all deaths and 5.7 per cent of total disability-adjusted life years (Pruss 2002). To reduce the childhood diarrheal morbidity and mortality, WHO and UNICEF (2009) have included at least three goals directly related to water and sanitation; (1) improved water supply quantity and quality, including treatment and safe storage of household water, (2) promotion of hand washing with soap and (3) community wide sanitation promotion, i.e. safe water, hygiene and sanitation in a 7-point action plan.

In India, diarrheal diseases continue to be an important cause of morbidity and mortality in under-fives despite various preventive and standardized case management strategies. It was estimated that in 2005, 302000 children age 1-59 months died due to diarrheal diseases giving a mortality rate of 11.1 per 1000 live births (Basinet al.2010.). Nearly three quarter of child deaths due to diarrhea occur in just 15 countries of the world and it is very sad that India tops the list (WHO 2008). The transition from unimproved to improved sanitation is accompanied by a more than 30 percent reduction in child mortality (UNDP 2006). Economic impact of inadequate sanitation, in addition to health, also includes cost in the form of productivity loss, cost of fetching water, lost tourism earning and cost of treatment of water etc. The magnitude of loss due to inadequate sanitation in

India accounts to Rs.2.44 trillion (US\$ 53.8 billion) a year which was the equivalent of 6.4 per cent of India's GDP in 2006. This means a per person annual impact of Rs.2180 (US \$48). Losses incurred on account of inadequate sanitation were as high as the state income of Andhra Pradesh or Tamil Nadu and were more than Gujarat's state income in 2006-07. The health related economic impact alone pegged at Rs.1.75 trillion (US \$38.5 billion) accounting for the largest category of impacts. Access time (productive time lost to access sanitation facility) and drinking water related impacts are the other two main losses, at Rs.487 billion (US \$10.7 billion) and Rs.191 billion (US \$4.2 billion) respectively (Tyagiet al. 2006).



Source: Tyagiet al. 2006

Figure- 1: Economic impacts of inadequate sanitation in India, by categories

In this backdrop, this paper attempts to examine the scenario of access to safe drinking water and sanitation in twenty major Indian states with an objective to analyse whether the differences in the sanitary conditions could explain differential health outcomes. The paper, therefore, builds on the hypothesis that the states where a significant proportion of population has access to safe drinking water and sanitation achieve better health outcomes.

The analysis is carried out for 2011, census data for which has very recently come out. State wise data for accessibility to water and sanitation has been taken from houses, household amenities and assets tables of Census of India, 2011. Twenty major states of India considered for the analysis include Andhra Pradesh, Assam, Bihar, Chhattisgarh, Delhi, Gujarat, Haryana,

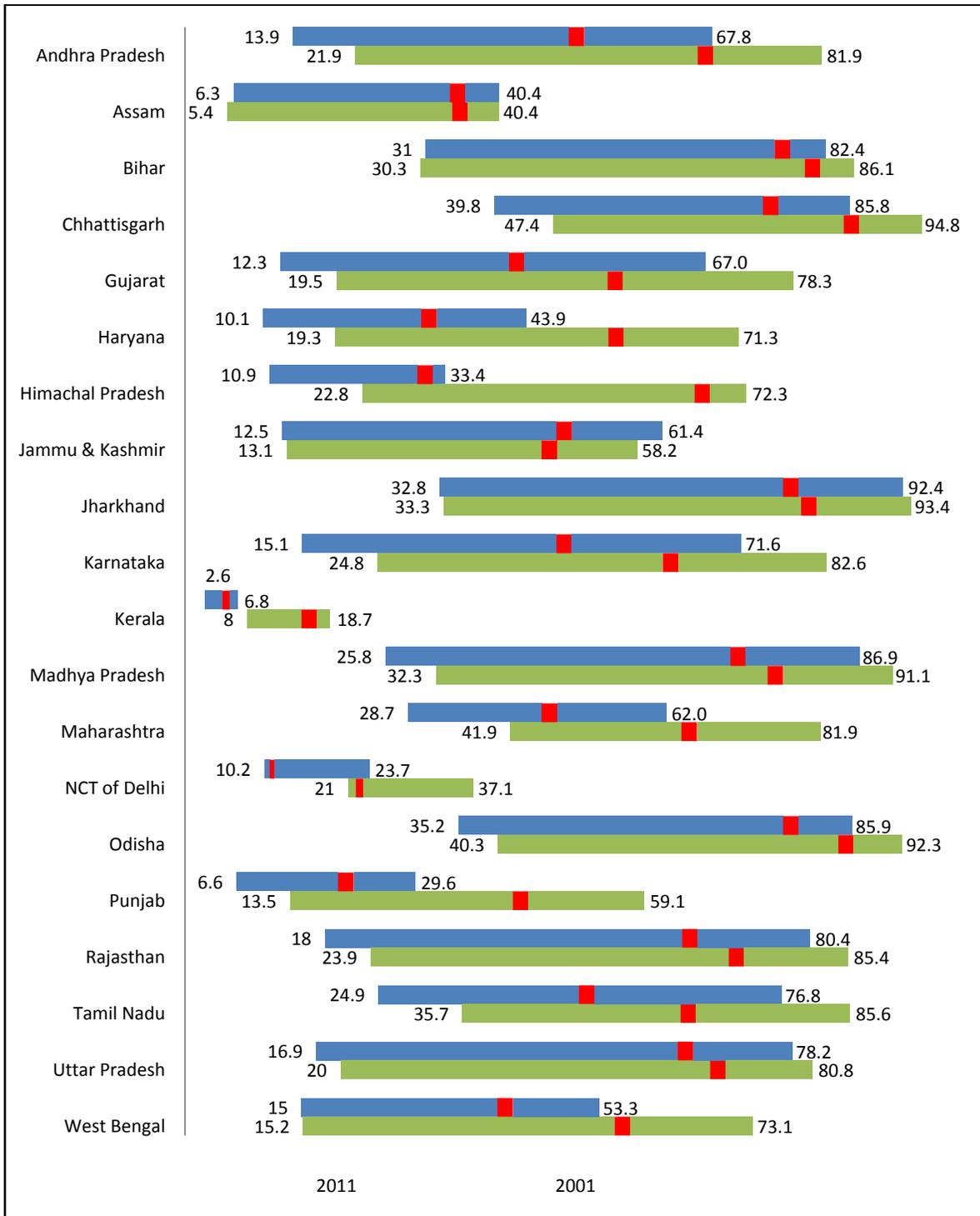
Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, and West Bengal.

The remainder of this paper is structured into the following four sections: Section II provides a broad overview of access to safe water and sanitation in major Indian states and regional variations therein. Section III details the methods to probe the linkage of drinking water, sanitation and health. Section IV discusses the index of sanitation and analyses differences in health outcomes due to differences in sanitary conditions and also attempts to locate the achievements in water, sanitation and health and profiles the status in different groups of Indian states. Conclusions and broad inferences are presented in section V.

Access to Safe Drinking Water and Sanitation: An Analysis

Drinking water and sanitation are two basic and most important items of social basket that are required by every human being for bare minimum living. Providing safe drinking water and proper sanitation to millions of Indian people is really a big challenge. According to the latest data, in India 92 per cent people have access to improved source of drinking water, whereas only 34 per cent people have improved source of sanitation (WHO 2012). This is reflected in India's poor health outcomes, such as infant mortality rate, child mortality rate, communicable diseases and overall morbidity. In India, rural-urban disparity in access to safe drinking water and improved sanitation is quite evident from 2011 census data. In urban areas, people to a large extent depend upon water supply systems that

either draw from proximate surface water bodies or draw sub-surface water. Water treatment plants are either lacking in many areas or are maintained inadequately. There are very few areas having continuous water supply and many cities face the problem of infrequent and irregular water supply. Poor and slum areas have the sharing points of water supply such as public taps and tube wells which cater to the underserved households. Over the past, significant improvements have been witnessed but it remains inadequate in terms of overall coverage and good quality due to rapid urbanization and low resource allocation, among other factors (Mahal 2010). In rural areas, shared hand pumps, tube wells and tap water are commonly found as main source of drinking water.

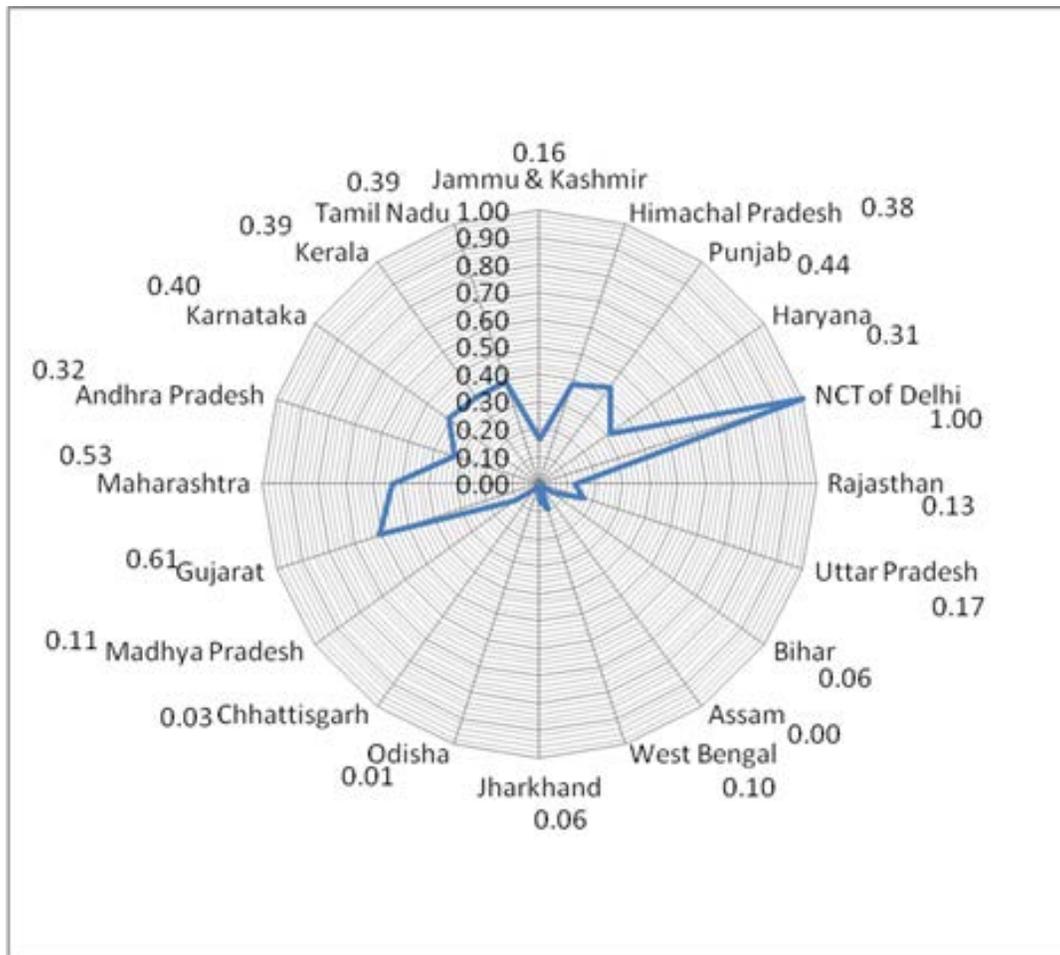


Source: Based on data from Census of India, 2011.

Figure-2: Change over a Decade in “No Latrine Facility”

So far as sanitation is concerned; people from urban areas mainly depend on sanitation system or septic tanks for disposal. However, it is quite unfortunate that even today, these are inaccessible to many people and as a result they have been depending on open defecation especially in poor and slum areas (Fig. 2). In rural areas open defecation is very common. Drainage

system is non-existent in many areas, which results in contamination of surface and sub-surface water, making it polluted (Fig. 3). Closed drainage systems in rural areas need much more improvement. Besides, lack of awareness about hygiene and poor habits make the situation worse.



Based on author's calculations.

Figure –3: Interstate variation in closed drainage, 2011

Table 1: Descriptive statistics

Households having access to “safe drinking water”						
	Total		Rural		Urban	
	2001	2011	2001	2011	2001	2011
Average	38.26	45.78	27.96	36.49	64.78	66.36
Std. Dev.	24.31	27.61	23.51	27.55	19.21	22.22
C. V.	63.53	60.32	84.09	75.51	29.66	33.48
Rural urban difference 2001 t value (-11.174*) 95% confidence interval (-43.72 - -29.92)						
Rural urban difference 2011 t value (-08.471*) 95% confidence interval (-37.26 - -22.49)						
Households having “water closet latrine facility”						
	Total		Rural		Urban	
	2001	2011	2001	2011	2001	2011
Average	19.03	39.81	8.55	25.64	45.71	72.68
Std. Dev.	14.26	18.12	13.23	18.10	11.01	9.15
C. V.	74.94	45.51	154.84	70.63	24.09	12.59
Rural urban difference 2001 t value (-18.51*) 95% confidence interval (-41.36 - -32.95)						
Rural urban difference 2011 t value (-15.82*) 95% confidence interval (-53.26 - -40.82)						

*refers to 1% level of significance

Table 1 shows stark disparities in coverage in rural and urban areas in major states of India, illustrating the challenges in

equitable achievement of the MDGs. Over 117 million rural households still lack access to safe water. The significant increase in the urban households that gained access to improved

water sources over the decade is well over 18.7 million. However, the urban dwellers using unimproved sources actually increased from 16.8 million to 23.1 million households. This must be viewed in relation to the massive growth in urban population over the same period – rising from 56.3 million to 78.8 million households. Though the ratio of households in rural areas with access to safe water has improved substantially since 2001, the number of households using alternative sources in 2011 was still five times greater (116 million) in comparison to urban areas (23 million). Variation in the rate at which major states have increased access to safe water is striking.

People in urban areas enjoy better conditions with 45 percent households having closed drainage connectivity for waste water outlet, and around 77 percent households having improved latrine and bathroom facilities. Unfortunately, even moderate facilities are not available in rural areas and half of rural dwellers still depend on open defecation. The ratio ranges between 70-77 percent in states like Bihar, Jharkhand, Odisha, Chhattisgarh and Madhya Pradesh. Much higher percent of households have mobile phones and televisions in these states. It is an evidence of misplaced priorities and lack of awareness.

Table 1 also shows strong rural urban differences in the levels of access to safe drinking water and sanitation. People in urban areas are far more likely to have both the facilities. For example, in high income states like Punjab and Haryana, percentage of households having water closet latrine is 85.6 and 80.5 respectively while the corresponding figures for rural areas are 42.7 and 32.6. The difference is disproportionately large in low income states like Rajasthan, Uttar Pradesh and Bihar. To analyse the structural differences in the accessibility of safe drinking water and sanitation across rural and urban areas, t-test for differences in means has been employed. The rural-urban differences have been found to be highly significant for both water and sanitation for both the points of time i.e. 2001 and 2011.

II. METHODS

Improvements in water supply and sanitation along with effective hygiene education play a major role in reducing high levels of morbidity and mortality in many poor countries (Jalan and Ravallion 2001; World Bank 2006). Access to drinking water and sanitation is both a human rights issue and a key development challenge that has profound health and gender

implications. Women and girls are typically responsible for managing water and sanitation at the household level, often walking several hours per day to collect water which increases their unpaid work hours and hinders their ability to engage in income-generating work or attending school.

National Health Policy recognizes the fact that water supply, sanitation and health are very much interrelated with each other. Health outcomes are positively affected by safe drinking water and improved sanitation. So, these issues should be dealt holistically. The benefits of safe drinking water cannot be realized without proper sanitation system and proper disposal of sewage. In case of open defecation or nonexistence of sewage system, surface and sub-surface drinking water tend to be contaminated. In absence of adequate water treatment plant this unsafe drinking water causes different water-borne diseases. So, it is important to maintain both the quality of water as well as proper sanitation system where sewage is disposed of in an appropriate manner, so that sources of drinking water are not contaminated. Evidently, both the provisions have forward and backward linkages.

Drainage, latrine and bathroom facilities together represent the sanitation facility here in the analysis. To prepare Index of Sanitation, these three indicators have been combined using the technique of Principal Component Analysis (PCA); it is a linear combination of weighted variables explaining 85.60 percent of total variance. With Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy being equal to .69 and Bartlett's test of sphericity being equal to 40.57 (p value .000), it is safe to prepare a composite index of sanitation. The Index of sanitation so derived has been then used in regression analysis – to investigate its impact on health, and also in cluster analysis – to prepare typology of sanitation and health.

To assess the extent of association among indicators reflecting lack of basic facilities such as percentage of household having no access to proper (improved) source of drinking water, percentage of household having no drainage facility, percentage of households having no latrine facility within the premise and percentage of households having no bathroom facility within the premise with major health outcomes like IMR, CMR and, U5MR, Spearman's rank correlation has been computed. The correlation matrix as presented in table 2 shows that all the correlation coefficients are highly significant and also with expected sign.

Table – 2: Correlation Matrix

	Bathroom Facility	Closed Drainage	Drinking Water	Latrine facility	CMR	U5MR	IMR	Index of Sanitation	No Bathroom Facility	No Drainage	No Latrine
Bathroom Facility	1.00	0.866 (0.000)	0.744 (0.000)	0.815 (0.000)	-0.653 (0.002)	-0.703 (0.001)	-0.634 (0.003)	0.943 (0.000)	-0.962 (0.000)	-0.777 (0.000)	-0.813 (0.000)
Closed Drainage		1	0.650 (0.002)	0.617 (0.004)	-0.641 (0.002)	-0.709 (0.000)	-0.657 (0.002)	0.869 (0.000)	-0.901 (0.000)	-0.798 (0.000)	-0.599 (0.005)
Drinking Water			1	0.827 (0.000)	-0.428 (0.060)	-0.425 (0.062)	-0.418 (0.066)	0.811 (0.000)	-0.789 (0.000)	-0.701 (0.001)	-0.847 (0.000)
Latrine facility				1	-0.624 (0.003)	-0.590 (0.006)	-0.587 (0.007)	0.908 (0.000)	-0.774 (0.000)	-0.550 (0.012)	-0.992 (0.000)
CMR					1	0.963 (0.000)	0.961 (0.00)	-0.729 (0.000)	0.620 (0.004)	0.459 (0.042)	0.602 (0.005)
U5MR						1	0.950 (0.000)	-0.739 (0.000)	0.670 (0.001)	0.510 (0.22)	0.573 (0.008)
IMR							1	-0.714 (0.000)	0.601 (0.005)	0.410 (0.073)	0.565 (0.009)
Index of Sanitation								1	-0.922 (0.000)	-0.713 (0.000)	-0.898 (0.000)
No Bathroom Facility									1	0.832 (0.000)	0.761 (0.000)
No Drainage										1	0.557 (0.011)
No Latrine											1

Author's calculation.

It is quite evident that access to drinking water and sanitation is positively correlated with IMR, U5MR and CMR while lack of these facilities bears negative relationship with health outcomes. Statistically high correlation between no access to drinking water and no latrine facility as well as between no access to drinking water and no bathroom facility signifies the inter relationship between drinking water and sanitation.

III. DISCUSSION AND RESULTS

Impressive health outcomes of a country is a concoction of so many factors such as adequate and motivated health workers, equitable and accessible health infrastructure, proper water supply and sanitation facilities with hygienic behavior, enough nutritional provision, especially for the children etc. All these factors to some extent influence health scenario of a country. Every year a huge number of children die due to water-borne or water related diseases. To analyses the impact of differentials in unsafe water and improper sanitation on Infant Mortality Rate (IMR), Under 5 Mortality Rate (U5MR) and Child Mortality Rate (CMR), regression analysis has been carried out, where index of sanitation is independent variable.

This section is devoted to test the nature of the relationship between water, sanitation, and health with the help of regression analysis first and then preparation of typology of sanitation and health. In all, three different models have been estimated with IMR, CMR and U5MR as dependent variables, respectively. Index of sanitation- a weighted average of drainage facility, bathroom facility and latrine facility- has been treated as an independent variable. The estimated coefficients of regression along with t- statistics, R square, adjusted R square and F values have been presented in Table- 3. From the estimated regression coefficients, it can be inferred that index of sanitation has highly significant positive effect on all the mortality indicators viz IMR,

U5MR and CMR. Further, the values of R square and adjusted R square in all three models are satisfactorily high conveying that index of sanitation have been an important factor affecting mortality rates. F values too have come out to be significant at 1 per cent level.

On the basis of the scores of the Index of Sanitation, drinking water and IMR, the states have been classified into three levels of performance viz., High, Moderate and Low using hierarchical cluster analysis. The classification of twenty states according to performance in three phenomenons has been presented in Fig. 4. Preparation of typology of water, sanitation and health is of great help in designing appropriate state-specific policy package. It is quite evident from the typology that the states which have a relatively better access to drinking water and sanitation enjoy better health outcome. On the contrary, the states which have a lower level of access to drinking water and sanitation experience poor health outcomes. The only state with diversified performance is Tamil Nadu with moderate health facility, low score of index of sanitation and still enjoying high performance in IMR.

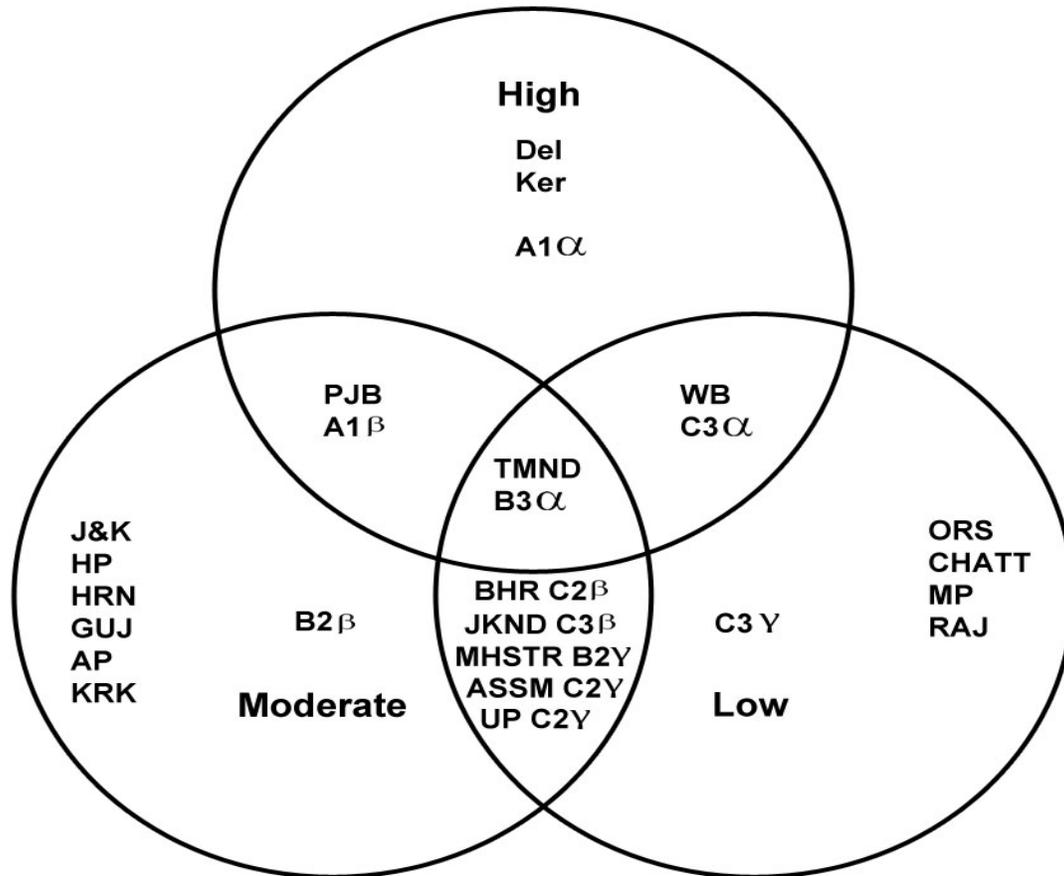
Table – 3: Regression Results

Dependent Independent	IMR	CMR	U5MR
Intercept	42.850* (18.929)	11.70* (14.487)	52.750* (16.889)
Index of Sanitation	-9.095* (-3.916)	-3.383* (-4.082)	-13.928* (-4.346)
R Square	0.460	0.481	0.512
Adjusted R Square	0.430	0.452	0.485
F Value	15.335*	16.665*	18.891*

Note: * Significant at 1 % level. Values reported in parentheses are t-values.

It's clear from the Figure -4 that only two states viz. Delhi and Kerala have a relatively higher level of water and sanitation facilities and also low IMR i.e. high performance on health. On the other side, the states of Odisha, Chhattisgarh, Madhya Pradesh and Rajasthan do not paint rosy picture. In these states, lower level of water and sanitation facilities is accompanied with lower level of health performance. Six states namely Jammu & Kashmir, Himachal Pradesh, Haryana, Gujarat, Andhra Pradesh and Karnataka exhibit moderate achievement in all the

indicators. Bihar, Jharkhand, Maharashtra, Assam and Uttar Pradesh show low and moderate performance. Focusing on these marginal states with low performance, and low- moderate performance might prove beneficial for improving national averages. West Bengal which performs high on IMR front has suffered a low level of sanitary facility. To sustain laudable health performance, water and sanitation merit immediate attention. Commendable example of Kerala suggests that large gains are possible given the political and institutional structures necessary to convert policy on universalizing access into a reality.



Based on Hierarchical cluster analysis
Figure- 4: Typology of Water, Sanitation and Health

Performance	High	Moderate	Low
Indicator			
Drinking water	A	B	C
Index of sanitation	1	2	3
IMR	α	β	γ

IV. CONCLUSIONS

Recently, the human and social handicaps that inadequate sanitation and unsafe drinking water pose for the people, especially the poor, has been recognized and improving access to drinking water and sanitation is now being given greater priority by the governments and civil societies. Poor coverage of drinking

water and sanitation facility in developing countries like India makes the life of the dwellers miserable. Presently the coverage of water supply and sanitation system is limited and much below the desired level, especially in the rural areas. Different factors related with each other have created such a deplorable situation. Initially, less priority was given to access to safe drinking water and improved sanitation. Along with this, limited financial

resources, lack of sustainability of water supply and sanitation services, unhygienic behaviors, and inadequate sanitation in public places such as hospitals, health centers and schools are responsible for this situation. Lack of proper sanitation facility is a serious health risk and insult to human dignity.

Adequate sanitation improves attendance in school, especially among the girls. Similarly, by improving source of water, a considerable amount of water-borne, water washed, water related diseases can be prevented. Besides treating the water, hygienic water storage is also very important. It is a duty of the government to ensure proper regulation in respect of industrial effluent and sewage treatment plant to prevent the surface and ground water contamination. Community participation also plays an important role in changing behavior. They can also play a crucial role in operation and maintenance of water treatment structure.

Recognizing the importance of safe drinking water and improved sanitation different policies have been made and actions have been taken to expand the access to these basic services. The Rajiv Gandhi National Drinking Water Mission (RGNDWM) is one of them. In order to provide adequate and proper quality of water in rural areas on a sustainable basis this initiative has been taken up. However, the national goal of ensuring adequate potable drinking water to the rural people at a convenient location at all times is yet to be achieved.

Water supply and sanitation are controlled by the central Ministry of Rural Development. The department of public health and engineering typically focuses on infrastructure creation such as installing hand pumps and tube wells, constructing toilets etc. But only infrastructure creation will not serve the purpose. It is equally important that infrastructure is accessible and usable by all. Much more attention is needed in ensuring quality services, generating public awareness, educating people about hygienic habits and making efficient use of scarce resources.

Study by Water and Sanitation Programme (WSP) estimates that a package of comprehensive sanitation and hygiene interventions can result in averting 45 per cent of adverse health impacts, and avoid all the adverse impacts of inadequate sanitation related to water, welfare and tourism losses. It estimates a potential gain of about Rs. 1.48 trillion (US \$32.6 billion) which was equivalent to 3.9 per cent of India's GDP in 2006. This signifies potential gain of Rs.1321 (US \$ 29) per capita (Tyagiet al. 2006).

Unaware of the significant positive externality, individuals generally leave drinking water and sanitation to the State to take care. It's also true that despite wide reaching ramifications, it has been vulnerable to budgetary restraints. Being root source of poor health, steps to scale up sanitation can help provide better value for money spent on health infrastructure and health delivery system. High rates of population growth and urbanization will further create growing challenges to cope with sanitary provisions for high density, low income populations. Commendable example of Kerala suggests that large gains are possible given the political and institutional structures necessary to convert policy on universalizing access into a reality. It's better to hit the trunk, branches will fall automatically.

For wider understanding of the significance of access to water and sanitation in socioeconomic development, sensitization is indispensable. Taboos surrounding the toilet and human

excreta hinder progress in this field. Therefore, a stronger appreciation of the manifold society wide benefits of sanitation and the challenges of achieving them is need of the hour. To promote safe hygienic practices at the household and community level and to create sustained behavioral change, innovative strategies must be evolved. For making toilet a desirable household good, the challenge is to offer both the poor and the non-poor a range of desirable and affordable options while persuading them to change their priorities so that improved sanitation becomes an attractive "must have" for every household.

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