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Burden of water, sanitation and hygiene related diseases in India: prevalence, health care cost and effect of community level factors

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ABSTRACT

Objectives: To study the disease burden and financial burden of water, sanitation and hygiene (WASH) related-diseases among individuals in India.

Methods: The prevalence and economic burden of WASH-related diseases was estimated using 75th Round National Sample Survey: 'Household social consumption: Health'. A multilevel logistic regression model was used to assess the effect of community level factors in the prevalence of these diseases.

Results: The prevalence of WASH-related diseases in India was at 5.7% of all outpatient visits and 6.9% of all hospital admissions during in 2017–18.66% of all outpatient malaria visits in rural areas were associated with restrictions in daily activities of ailing individuals. The mean out-of-pocket expenditure across all WASH-related diseases was ₹703 per outpatient visit and ₹9656 per hospital admission. The monthly OOOPE on outpatient care for 74% persons with jaundice in rural areas, was greater than their monthly per capita consumption expenditure and 97% persons with malaria in urban areas faced catastrophic OOOPE on outpatient care. Each hospital admission for jaundice in urban areas led to an earning loss of ₹2260. The intra-class correlation at community level from the multilevel logistic regression for diseases prevalence were 0.28 and 0.26 for outpatient and inpatient cases, indicating the role of community level factors in the variation in disease prevalence.

Conclusion: There is a high prevalence, financial burden and effect of community level factors on WASH-related diseases in India. Holistic strengthening of WASH facilities is required to mitigate the avoidable burden of these diseases.

1. Introduction

In 2010, the United Nations recognized safe water, sanitation and hygiene (WASH) as a human right. Goal 6 of SDGs is also related to universal attainment of WASH because of its essential role in public health. Yet even by 2019, 2.2 billion people lacked safe drinking water, 4.2 billion people lacked safe sanitation and 673 million people still practiced open defecation around the world.¹

This is a risk factor for many diseases¹ like diarrhoea, jaundice, vector borne diseases like malaria, filariasis etc. and neglected tropical diseases like helminths,^{2,3} due to infections by faecal–oral route, exposure to contaminated water and poor hygiene practices.²

In 2019, there were 98.8 million globally prevalent cases of enteric infections, contributing to 1.75 million deaths and 96.8 million DALYs.⁴

In 2016, the WASH-attributable disease burden was 4.6% of global DALYs and 3.3% of global deaths.⁵ Every year there are 11 million typhoid and 3 million cholera cases, in the world, out of which more than 1 million end up in fatality.⁶

Till 2014, open defecation was practiced by 65% of the rural population in India and only 14% of them had piped-in water in homes.⁷ While Clean India Mission that was launched in 2014⁸ by the Government of India successfully declared all rural areas as open defecation free in 2019,⁹ attainment of WASH facilities in terms of clean piped water into homes, treatment of sludge, disposal of garbage and a change in peoples' hygiene related practices like hand washing and using toilets at home, is still a work in progress.³

In India, 5% of all DALYs among all ages are caused due to WASH-related diseases. 78% of these DALYs are due to enteric infections

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¹ Referred to as WASH-related diseases in the paper.

² The aetiology of WASH related diseases is given in [Appendix Box 1](#).

³ Government of India has launched phase 2 of Clean India Mission for providing access to solid and liquid waste management and Jal Jeevan Mission with the aim of providing piped water in every home.

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attributable to environmental factors amounting to more than 1300 DALYs per 100,000 and the rest of them are attributable to behavioral factors in 2019.¹⁰ During 2010–13, 7.5% of deaths among all age groups in India were due to diarrhoea, malaria and some tropical diseases.¹¹ There were more than 1.32 crore cases of acute diarrhoeal disease, 24 lakh cases of typhoid and more than 5 lakh cases of vector borne disease like malaria, dengue, chikungunya in India in 2019.¹²

Occurrence of diarrhoea was found to be positively associated with socioeconomic factors and WASH facilities were identified as risk factors in Lusaka, Zambia.¹³ Diarrhoea was found to be the leading water borne disease in Godawari, Nepal, accounting for 48% of hospitalization cases with an out-of-pocket expenditure (OOPE) of 568 NR per episode, including a wage loss of NR 360 per episode by parents of those sick with diarrhoea.¹⁴ Malaria, typhoid and jaundice raised the expenditure incurred by households due to curative, preventive and curative time costs of environment related diseases in Nepal in 2016–17.¹⁵ Typhoid was also associated with highest health care cost (TK 1814.0) among acute illnesses and 24% catastrophic expenditure in Bangladesh.¹⁶ The average cost of treatment for each episode of dengue per household in Vietnam was found to be US\$ 61 in Vietnam,¹⁷ and US\$ 118 in Thailand.¹⁸

According to WHO, about 50–100 million dengue infections occur globally every year, 2.5% of which are fatal and most of the time it occurs as an outbreak.¹⁹ In 2014, as per the Directorate of the National Vector Borne Disease Control Program (NVBDCP)²⁰ about 95% of India's population resided in malaria-endemic area. In 2019, 341 diarrhoeal, 181 dengue, 72 chikungunya and 27 malaria outbreaks were reported in India.¹² The median value of OOPE per person for chikungunya was US\$84 in a village in India in 2007. This was accompanied by a median value of work days lost at 35 and income loss of US \$75.²¹ Kumar & Garg¹¹ showed that frequent outbreaks of Dengue occur in Delhi and surrounding regions involving a per patient cost of treatment at ₹11563.

The economic burden of malaria in India was estimated to be around US\$ 1940 million in 2004. The major burden was from lost earnings while the rest was from treatment costs.²⁰ The mean OOPE for each episode of hospitalization due to diarrhoea was estimated at ₹5473 and due to jaundice at ₹17794 in 2014. 15%–32% cases of distress financing were also reported for both these ailments across public and private facilities.²² For same year, the median household OOPE from hospitalization due to Filariasis was US\$ 178 and 30% of rich households experienced catastrophic costs.²³

WASH-related diseases are found to create a burden in India and other countries. However, national estimates of the burden due to all of these diseases for India are not known. Using the nationally representative household survey on health of 2017–18, this paper looks at the burden of all the WASH related diseases in India in terms of their prevalence, intensity, duration in terms of number of sick days, OOPE and earnings lost. This study also uses multilevel logistic regression modelling to assess the effect of contextual factors at the community level in the prevalence of such diseases and variation therein.

2. Methods

2.1. Data sources

The study used data from 75th round of National Sample Survey of India (NSS),⁴ namely, 'Household social consumption: Health'.²⁴ It is a nationally representative household survey conducted for the period 2017–18, containing information on types of ailments, health care utilization & expenditure, demographic & socio-economic information about households and their members. Self-reported information is

collected on health care expenditure and utilization for each episode of illness for a reference period of last 365 days for hospitalization cases and last 15 days for non-hospitalized cases. Information about prevalence of 61 types of well-defined ailments including childbirth is collected on the basis of reported diagnosis by qualified health care providers, and for some ailments if reported diagnosis is not available diseases are classified on the basis of main symptoms for which health care was sought. Though, many WASH related ailments tend to be seasonal in nature, the survey data have been collected in four sub-rounds of three months each during the entire year from July 2017 to June 2018, hence seasonality is not an issue for our study.

The survey uses a stratified multi-stage sampling design, where the first stage units (FSUs) are the census villages in the rural sector and urban frame survey blocks in the urban sector. The ultimate stage units are households in both the sectors. A total of 14300 FSUs, were allocated to the states in proportion to the most recent census population while ensuring that a minimum sample of 16 FSUs were surveyed in each state. Both rural and urban samples are drawn in the form of two independent sub-samples. This generated a sample size of 113823 households with 555352 individuals for All India. A total 326033 of these individuals reside in rural areas and 229319 are urban residents. This sampling design is most suitable for using multilevel modelling with individuals at the lowest level which are nested among FSUs which in turn are nested among states.

2.2. Outcome variables

Burden of disease has been assessed by prevalence of disease and intensity of ailment. Disease prevalence has been estimated as the proportion of population reporting ailment for each of these diseases. Intensity of ailments for those seeking non-hospitalized care, has been gauged in terms of (i) the number of days for which a person was ailing, (ii) proportion of ailing population facing restrictions in usual activity, and (iii) proportion of ailing population confined to bed. For those seeking hospitalized care, intensity was measured as the number of hospital admission days.

Financial burden of disease has been looked at in terms of out-of-pocket expenditure (OOPE), household earnings lost, proportion of outpatient visits and hospital admissions where monthly value of OOPE was greater than MPCE, and proportion of outpatient visits and hospital admissions experiencing catastrophic OOPE. OOPE has been measured as the total expenditure incurred on the treatment of a disease after subtracting any reimbursement that may have been received. Earnings lost is measured as per the reported data in the survey. OOPE was considered as being catastrophic if the share of monthly OOPE in MPCE was greater than 10%.

All measures for disease burden and financial burden were estimated separately for each disease, disaggregated by types of service-outpatient or inpatient and by place of residence-rural or urban. Disaggregated measures permit a more nuanced and detailed analysis.

2.3. Data analysis

Descriptive statistics, bivariate estimates and multilevel logistic regression estimates were used for the analysis in the study. Descriptive statistics and bivariate estimates were used to assess disease burden and financial burden by socioeconomic characteristics. Multilevel logistic regression model was employed to examine the socioeconomic determinants of the prevalence of disease, while taking into account the hierarchical structure of the data.

Population weights were used to arrive at nationally representative estimates of OOPE and disease prevalence for each of the WASH-related diseases, at combined All India level and disaggregated rural and urban levels. Separate estimates were carried out for inpatient and outpatient cases since data were both these types of cases were collected using different reference periods. Box-1 in Appendix-1 gives a description of

⁴ NSSO is a national organization of the Government of India, Ministry of Statistics & Programme Implementation.

those disease categories that can be related to the lack of water, sanitation and hygiene facilities and for which information was collected in the Survey. OOPE was taken to be zero for all those users who got free treatment. All estimates were carried out in Stata 14.2 (StataCorp LP, College Station, TX, USA).

2.4. Multilevel logistic regression

Complementarities and externalities between water and sanitation interventions due to epidemiological and behavioral factors give rise to interlinkages and multiple pathways for transmission of WASH related diseases in the local sanitation environment.²⁵ Variations in the prevalence of these diseases can be attributed to the characteristics of the population and the contextual effects that arise from the environments of these groups of at the community level.

Multilevel modelling (MLM) helps to assess the variations in disease prevalence that can be attributed to contextual effects while controlling for population characteristics. Since the contextual effects in the incidence of disease are treated as coming from the survey population itself, the random part for the higher levels in MLM helps to capture the contextual effects across communities without using a multitude of community level parameters in the fixed part of the model.²⁶ The fixed part can be used to identify the characteristic effects of the population on the disease prevalence.

Exploiting the multistage stratified sampling design of the survey data, three-level logistic random-intercept multilevel logistic regression model was used to assess the influence of these unobserved community level and regional level⁵ heterogeneity in the prevalence of WASH-related diseases while controlling for observed individual and household level factors. The observed individual and household characteristics were used to model the fixed part. The dependent variable used in the model is: whether a person is ailing from WASH disease or not. Expression (1) depicts the estimated model.

$$\ln \frac{p_{ics}}{1-p_{ics}} = \alpha + \beta x_{ics} + (\delta_{ics} + \varepsilon_{cs} + \mu_s) \rightarrow \rightarrow \rightarrow (1)$$

The left hand side in (1) is the log of odds of the disease prevalence and p_{ics} is the probability of individual i in community c and state s of suffering from any WASH disease; the terms in the parentheses denote the random parts at level 1 (δ_{ics}), level 2 (ε_{cs}) and level 3 (μ_s) respectively; α is the mean intercept parameter; β is the vector of mean slope parameters corresponding to the various characteristics of individual i in community c and state s , i.e. x_{ics}

The correlations between the probability of WASH disease in the same community (ICC_c) and state (ICC_s) can be assessed by intra class correlation coefficients which are estimated as

$$ICC_c = \frac{\sigma_c^2 + \sigma_s^2}{\sigma_c^2 + \sigma_s^2 + 3.29} \quad ICC_s = \frac{\sigma_s^2}{\sigma_c^2 + \sigma_s^2 + 3.29}$$

with σ_c^2 being the community level variance and σ_s^2 being the state level variance.²⁷ Two logistic multilevel models were used, the null model without any explanatory variables and a model with covariates at level 1.

Ethical approval

Since the study is based on a household survey data available in public domain, ethical approval for the study was not needed.

3. Results

The share of all the WASH- related diseases taken together is quite high at 5.7%–6.9% among all outpatient and inpatient ailments

respectively, at All India level (Table 1). For both outpatient and inpatient cases, the prevalence for all these ailments is higher in the rural areas than urban areas. Among the outpatient cases, the share of skin infections and diarrhoea are the highest. The proportion of diarrhoea cases is also the highest among hospital admissions, followed by malaria and jaundice. Not only do these ailments impose a disease burden and financial burden on the population, they also lead to loss in productivity, as demonstrated by the number of days for which people were confined to bed or could not carry out their usual activities (Table 2). In the rural areas for outpatient cases, among all the persons suffering from malaria, more than 66% could not carry out their usual activity and more than 50% were confined to bed. Severity of disease was also high for persons suffering from filariasis and jaundice. The effect of filariasis is not only severe but also prolonged as reflected in the mean number of days for which a person was sick or hospitalized. Undernutrition or worm infestation are found to have prolonged periods of illness.

For non-hospitalized cases, the mean OOPE in both rural and urban areas is greater for WASH-related diseases in contrast to mean OOPE for rest of the diseases across all types of providers (except informal care in urban areas). Table 3 shows that the mean OOPE for WASH-related diseases is much higher for private providers as compared to public providers for both outpatient and inpatient cases. A considerable value of mean OOPE for informal or self-care indicates that people have a tendency to either seek care by an informal provider or do a self-medication by consulting friends or chemist shops for these commonly occurring infectious diseases. Highest OOPE across all providers is seen for jaundice in both rural and urban areas, while malaria has the highest OOPE on account of informal or self-care. The OOPE for all these ailments taken together across all providers and regions is ₹703 while the mean OOPE for rest of the diseases is ₹680.

Compared to mean OOPE per hospitalization on rest of the diseases at ₹17065 mean OOPE for WASH-related diseases is lower. Yet it is quite high at ₹9656 per hospital admission. Among all the WASH diseases, the mean OOPE for each episode of hospitalization, is highest for filariasis and skin infections in rural areas at ₹16061 and ₹15236 respectively. In urban areas the corresponding OOPE values on these two diseases is even higher at ₹41526 and ₹33198 respectively.

In addition to the financial burden of treatment that individuals face in the form of OOPE and which 95% or more individual pay out of their savings or current income, they also face the burden of earnings loss because of the inability of the sick person or the care-giver in the family to go to work. Table 4 shows that filariasis and malaria inflict a heavy burden on this account for both outpatient and inpatient cases. Diarrhoea comes at the third place in case of outpatient cases while jaundice causes the third highest loss in income in cases of inpatient ailments. Table 4 also shows that the OOPE per episode converted into monthly value was greater than monthly per capita consumption expenditure (MPCE) for 46%–55% outpatient visits in rural and urban areas. In case of outpatient visits for jaundice in the rural areas, 74% visits entailed OOPE greater than MPCE. This figure ranged from 25% to 29% for hospital admissions on account of filariasis. 96%–97% of outpatient visits for malaria and 97%–95% outpatient visits for jaundice in the rural and urban areas involved catastrophic expenditure. For diarrhoea, the corresponding estimates were 87%–76% for rural and urban areas respectively. In case of hospital admissions, 61%–57% malaria, 82%–67% for filariasis and 78%–70% diarrhoea admissions involved catastrophic expenditure.

Effect of community level factors on the prevalence of WASH-related diseases.

To assess the overall degree of homogeneity in falling sick with WASH-related diseases among individuals within a community and a

⁵ Communities were determined on the basis of first stage sampling units in the data and states of India were used to identify regions.

Table 1
Share of WASH-Related ailments in total ailments (%).

WASH-related ailment	Outpatient				Inpatient			
	Rural	Urban	All India	n	Rural	Urban	All India	n
	(%)	(%)	(%)		(%)	(%)	(%)	
Malaria	1	0.5	0.8	363	2.1	1.6	1.9	1783
Filariasis	0.1	0.1	0.1	23	0.1	0	0.1	56
Jaundice	0.2	0.1	0.2	80	1.4	1.5	1.4	1328
Diarrhoea	2	0.9	1.6	682	2.5	2	2.4	2227
Worms infestation	0.2	0.1	0.1	54	0.1	0.1	0.1	92
Undernutrition	0.1	0.1	0.1	39	0.1	0.1	0.1	74
Eye infection	0.7	0.3	0.6	248	0.5	0.3	0.4	390
Skin infection	2.7	1.6	2.3	991	0.6	0.7	0.6	564
All WASH diseases	6.9	3.6	5.7	2480	7.2	6.4	6.9	6514

Source: Author's estimates.

Note: WASH is water, sanitation and hygiene.

Table 2
Intensity of WASH-related diseases during the reference period.

Ailment	Outpatient						Inpatient	
	Rural			Urban			Rural	Urban
	Mean number of days ill during reference period	% of ailing persons with restricted activity during reference period	% of ailing persons confined to bed during reference period	Mean number of days ill during reference period	% of ailing persons with restricted activity during reference period	% of ailing persons confined to bed during reference period	Mean number of days of hospitalization during reference period	Mean number of days of hospitalization during reference period
Malaria	7	66	51	7	58	51	5	5
Filariasis	14	48	45	15	54	33	9	9
Jaundice	10	34	21	13	36	34	6	7
Diarrhoea	4	52	39	4	47	21	3	3
Worms infestation	10	5	5	9	15	15	5	6
Undernutrition	11	2	0	8	9	8	6	8
Eye infection	7	40	6	8	41	22	4	4
Skin infection	13	6	2	10	19	6	7	7

Source: Author's estimates.

Note: WASH is water, sanitation and hygiene.

region,⁶ we estimated the random intercept multilevel logistic regression model at three levels without including the observed covariates and calculated the intra-community correlation. The intra-community correlation was estimated to be 0.32 for outpatient and 0.25 for inpatient sample respectively⁷ indicating a high degree of clustering in the prevalence of WASH related diseases in a community. A three-level random intercept logistic model is then estimated while controlling for the observed individual and household level factors at level 1.

Table 5 shows the results of three-level random intercept logistic regression model. The fixed part shows the odds ratios of falling sick for outpatient and inpatient ailment for various individual and household characteristics. The odds of prevalence of disease are higher for males compared to females. For outpatient cases, the odds ratio for persons with higher education is greater for outpatient cases but lower for inpatient cases. The chi-square statistic for the LR test for the multilevel logit regression is significant at 1% level indicating that in comparison to

the fixed intercept logistic model, the random intercept model is better. This in turn suggests that the individual's likelihood of falling sick with WASH-related diseases is jointly determined by the observed socio-economics characteristics as well as unobserved community-level factors. The effect of community level factors in the prevalence of WASH related diseases is quite high as depicted by the intra class correlation (ICC), indicating that 26%–28% variance of the residuals in inpatient cases and outpatient cases is explained due to level 2, i.e. the first stage sampling units (FSU) in the data. Community or village level factors relating to piped water at home and use of clean fuel have also been found to affect educational attainments.²⁸

4. Discussions

Nationally representative comprehensive studies on the out-of-pocket expenditures of all the major WASH related disease prevalent in India, are not known. This paper is an attempt to fill this gap by looking at the nationally representative burden of WASH related diseases in India for 2017–18.

Among all the reported outpatient ailments, 5.7% ailments are identified as WASH-related diseases and among the inpatient ailments the share of these diseases was 6.9%. Among all the WASH-related diseases, diarrhoea was the leading cause of hospitalization (34%) and the second highest cause of non-hospitalized ailments (27%). Filariasis has the longest duration of ailment with mean hospitalization duration at 9 days and mean number of sick days at 14 during the reference

⁶ Communities were determined on the basis of first stage sampling units in the data, which were villages in rural areas and urban blocks in urban areas. Regions were identified on the basis of states.

⁷ The likelihood test leads to the rejection of the single level logistic model in favor of the random intercept logistic model, for both outpatient and inpatient samples by rejecting the null hypothesis that the standard deviation of the random intercept term is zero at $p = 0.00$ with chi-square values being equal to = 797.5 & 1837.9 for outpatient and inpatient regressions respectively.

Table 3
Mean OOOPE (₹) per episode-for WASH related diseases-by types of care, providers and region.

Type of provider→ Ailment↓	Outpatient								Inpatient					
	Rural				Urban				Rural			Urban		
	Public	Private	Informal care/ self care	All providers	Public	Private	Informal care/ self care	All providers	Public	Private	All providers	Public	Private	All providers
Malaria	770 [573–967]	1102 [954–1250]	789 [470–1107]	990 [876–1104]	1047 [584–1511]	1521	1709 [229–3189]	1392	2190 [1163–1621]	15022 [12564–17480]	7256 [6288–8223]	2384 [1933–2835]	13156 [11605–14707]	8545 [7581–9510]
Filariasis	768 [(-) 192–1728]	779 [454–1105]	74 [(-)11–158]	663 [274–1052]	663 [(-) 393–1719]	1032 [(-) 242–2305]	–	783 [76–1490]	6556 [1797–11315]	21471 [12627–30315]	16061 [10757–21365]	8843 [(-) 8450–26136]	77696 [14650–140743]	41526 [7112–75941]
Jaundice	899 [641–1157]	1421 [1106–1735]	523 [261–786]	1235 [1018–1451]	1727 [1173–2282]	2556 [1457–3654]	437 [181–693]	2052 [1272–2833]	4588 [3959–5216]	19228 [16346–22109]	12268 [10760–13775]	3833 [3210–4456]	21756 [18977–24535]	14856 [13059–16653]
Diarrhoea	484 [374–593]	610 [416–804]	397 [275–519]	529 [426–633]	479 [220–737]	760 [597–923]	241 [124–358]	576 [462–690]	1875 [1715–2036]	8270 [7436–9103]	4263 [3932–4594]	1331 [1180–1482]	11730 [10286–13175]	5696 [5007–6386]
Worms infestation	370 [185–556]	530 [280–780]	109 [47–171]	420 [264–575]	656 [105–1206]	1047 [520–1575]	200	855 [488–1222]	9685 [1387–17983]	14658 [9600–19715]	12576 [7880–17273]	6380 [3749–9011]	55853 [37025–74681]	39261 [25743–52779]
Undernutrition	894 [684–1105]	831 [478–1184]	–	873 [696–1050]	305 [(-) 132–742]	1630 [1217–2044]	–	1459 [1087–1831]	2471 [1407–3534]	15696 [9183–22209]	8416 [5144–11689]	1675 302–3048	35794 21548–50041	19384 10115–28653]
Eye infection	700 414–987	743 581–905	97 (–)21–215	645 511–779	439 305–573	1856 457–3255	363 24–701	1175 392–1957	5443 4633–6254	19847 12561–27132	11752 8053–15451	1562 [649–2475]	20751 [11004–30498]	14714 [7973–21454]
Skin infection	525 [353–697]	748 [673–823]	242 [167–318]	593 [530–655]	325 [108–542]	829 [705–953]	157 [78–236]	643 [546–740]	5165 [3858–6471]	25512 [19870–31154]	15236 [12387–18084]	13869 [2207–25532]	43685 [21247–66124]	33198 [18198–48198]
All WASH ailments	605 [525–686]	795 [728–862]	313 [250–377]	661 [615–707]	1096 [925–1213]	589 [450–728]	285 [173–397]	841 [742–940]	2949 [2750–3149]	15290 [14050–16529]	8226 [7695–8758]	3238 [2264–4212]	21154 [18044–24263]	13065 [11317–14814]
Other diseases	424 [400–448]	865 [820–910]	283 [245–321]	639 [612–665]	425 [342–507]	920 [886–953]	341 [265–417]	749 [718–781]	4191 [4053–4329]	28061 [27387–28736]	14576 [14262–14890]	5093 [4828–5359]	33170 [32348–33992]	22300 [21799–22821]

Source: Author's estimates.

Notes OOOPE is out of pocket expenditure, WASH is water sanitation and hygiene.

Figures in bracket indicate 95% confidence interval.

- indicate no observations.

Table 4
Financial stress due to WASH related diseases.

WASH-related ailments	Loss in household earnings(₹) - per episode				Episodes with monthly OOOPE greater than MPCE (%)				Episodes with catastrophic expenditure (%)				
	Rural		Urban		Inpatient	Rural		Urban		Rural	Urban		Urban
	Outpatient					Outpatient visits		Hospital admissions		Outpatient visits		Hospital admissions	
Malaria	390 [295-484]	167 [85-249]	1384 [1158-1610]	1023 [939-1106]		54.9 [47.8-61.9]	45.6 [36.1-55.1]	7.9 [6.4-9.3]	2.7 [1.5-3.9]	96.2 [93.5-98.9]	97.3 [94.2-100.4]	60.8 [58.1-63.5]	56.8 [53.2-60.5]
Filariasis	406 [198-615]	481 [-168- 1130]	1769 [527-3011]	1806 [1128-2483]		11.4 [-1.3- 24.2]	19.3 [-4.1- 42.6]	28.8 [15.6-42.0]	25 [-0.6-50.6]	75 [57.7-92.3]	59.3 [30.2-88.4]	81.8 [70.5-93.0]	66.5 [38.6-94.4]
Jaundice	95 [21-168]	494 [145-844]	2260 [1860-2660]	1564 [1369-1760]		73.9 [64.7-83.0]	42.9 [28.9-56.9]	17.8 [15.2-20.3]	12.6 [9.9-15.2]	96.8 [93.1-100.5]	94.4 [88.0-100.9]	78.4 [75.6-81.1]	70.3 [66.6-74.0]
Diarrhoea	154 [118-190]	191 [109-272]	577 [504-649]	635 [583-687]		19.8 [15.6-24.0]	6.6 [3.3-9.9]	3.2 [2.3-4.0]	2.9 [1.8-3.9]	86.9 [83.- 90.5]	75.7 [70.0-81.4]	54.7 [52.3-57.2]	40.3 [37.3-43.4]
Worms infestation	42 [-53- 136]	28 [-53-109]	2792 [1656-3928]	1420 [742-2098]		21.9 [6.0-37.8]	41.7 [17.5-65.9]	21.4 [11.6-31.3]	30.2 [18.8-41.7]	100 [65.8-101.9]	83.9 [65.8-101.9]	68.9 [57.9-80.1]	84.2 [75.2-93.3]
Undernutrition	71 [-19- 161]	20 [-54-95]	795 [327-1263]	901 [289-1513]		67.3 [39.5-95.0]	48.7 [29.1-68.3]	6.9 [-0.8- 14.6]	9.9 [-0.1- 20.0]	99 [104.8-88.9]	88.9 [76.6-101.2]	79.1 [66.8-91.4]	56.8 [40.2-73.5]
Eye infection	147 [103-191]	184 [17-351]	1004 [563-1444]	1752 [865-2639]		27.4 [19.3-35.6]	14.6 [6.6-22.6]	10.8 [6.3-15.3]	2.6 [-0.1-5.3]	78.4 [70.9-85.9]	71.3 [61.1-81.6]	83.9 [78.5-89.2]	67.2 [59.2-75.2]
Skin infection	89 [17-161]	109 [55-163]	1467 [1079-1854]	2075 [1677-2472]		23.9 [19.9-27.8]	15.6 [11.7-19.4]	25 [20.5-29.6]	10.8 [7.2-14.4]	76.9 [73.0-80.8]	74.1 [69.5-78.8]	70.4 [65.5-75.2]	67.9 [62.5-73.2]

Figures in bracket indicate 95% confidence interval.

Source: Author's estimates.

Table 5

Regression results for random intercept logistic model for incidence of WASH-related diseases.

	Outpatient		Inpatient	
	Odds ratio	Standard error	Odds ratio	Standard error
Fixed part				
<i>Individual characteristics</i>				
Gender (Ref: female)				
Male	1.23***	0.06	1.84***	0.05
Marital Status (Ref: single)				
Married	0.84**	0.06	0.51***	0.02
Age groups in years (Ref: under 5 years)				
6-19 years	0.97*	0.09	0.87**	0.05
20-60 years	0.65***	0.06	0.46***	0.03
Above 60 years	0.34***	0.03	0.40***	0.02
Education Level (Ref cat: illiterate)				
Upto primary	0.97	0.07	0.79***	0.03
Primary to Middle	1.02	0.09	0.67***	0.03
Secondary and above	1.05	0.08	0.57***	0.03
<i>Household characteristics</i>				
MPCE ^{#1}	0.99***	0.00	0.99**	0.00
Household size	1	0.01	0.94***	0.01
Location (Ref cat: rural)				
Urban	0.84***	0.05	0.94*	0.03
Constant	0.08***	0.01	0.26***	0.03
Random Part				
Variance of random intercept terms				
State (Level3)	0.389	0.113	0.286	0.076
Community (Level2)	0.871	0.088	0.852	0.046
Log likelihood	-7854.2508		-22311.715	
Number of Level 1 units	43219		91449	
Number of Level 2 units	9749		14173	
Number of Level 3 units	36		36	
	518.9***		1742.6***	
LR Test chi-sq				
Intra class correlation				
State (Level3)	0.09	0.023	0.06	0.016
Community (Level2)	0.28	0.023	0.26	0.015

Source: Author's estimates.

Notes #Monthly per capita consumption expenditure.

*** p < 0.01, **p < 0.05, *p < 0.1.

period. Malaria led to greatest restriction on usual activities due to sickness with 66% persons with malaria reporting restricted activity in the rural areas.

Malaria also had the highest OOOPE per episode for outpatient cases in urban areas (₹1709). Jaundice had the highest level of OOOPE per episode for outpatient treatment at private facilities in both rural and urban areas (₹1421 - ₹2556). Filariasis had the highest OOOPE per episode of hospitalization. Other studies^{19,20,22,23} have also reported high cost of treatment and economic burden due to diseases like malaria, filariasis, jaundice and dengue.

Loss in household earnings due to sickness added to the economic burden caused by OOOPE. This burden per episode was highest for filariasis for outpatient treatment in rural areas. Jaundice was also associated with the highest earning loss for hospitalized ailments, both in rural and urban areas, at ₹1564 and 2260 respectively. It is possible that the burden of these ailments is higher than what has been estimated because a significant proportion of population may not seek care.²⁰ Given the long duration of sickness for some of these ailments as reported in Table 2, it could translate into a huge burden at a macroeconomic level in terms of work days lost, earnings forgone and healthcare expenditure incurred. Such a burden is likely to affect the vulnerable sections of population even more adversely.

5. Conclusion

The financial and disease burden due to all these ailments can be mitigated by having provision of proper toilets, piped drinking water, treatment of sludge and disposal of garbage. A study of these diseases is important because these diseases tend to be endemic in the local area and proactive public health policies for prevention of these diseases can avoid the burden caused by them. Many of these diseases also don't have any prescribed treatment protocol¹⁹ so the focus should be on prevention rather than cure.

The LR test for multilevel regression model was significant at $p < 0.01$ leading to the rejection of the fixed effect regression model in favor of a random intercept model, and the intra class correlation coefficients for inpatient and outpatient cases were greater than 25% indicating a role of contextual factors in the prevalence of WASH ailments. This underscores the importance of taking a comprehensive approach towards provision of WASH facilities and regular surveillance of disease outbreaks to mitigate the burden of these diseases. Programs such as Clean India Mission have been successful in creating 100% open defecation free spaces in all the districts of India, but the greatest reduction in the burden of sanitation related diseases will be felt only after the culmination of programs like Jal Jeevan Mission²⁹ and second phase of Swachh Bharat. Attention also needs to be paid to the quality and regularity of surveillance of these diseases, which are mandated for the local civic agencies.

5.1. Strengths and limitations

This is the first known study to take a look at the prevalence and OOPE of water, sanitation and hygiene related diseases in India. These

estimates are nationally representative and can provide a benchmark for monitoring the success of the various government missions related to sanitation and drinking water that have been launched in recent times.

Some limitations of the study remain. The study could not study the burden of all vector borne diseases like dengue and chikungunya, and water borne diseases like typhoid because information for them was clubbed together with other non-specific ailments like fever due to undiagnosed causes in the Survey data. The study also could not isolate the impact of policies like elimination of open defecation in India on disease incidence because it is a cross-section survey of individuals and not a time-series data of communities with information on diseases before and after the such policies. But the results of the intra class correlations in the random intercept model indicate that a complete package of all these services together have an influence on the prevalence of all these diseases.

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Declaration of competing interest

None.

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APPENDIX

Box 1

Aetiology of Wash Attributable Diseases	
Disease classification	Types of diseases
Water borne	Diarrhoea, Typhoid, Jaundice, Cholera, Helminths
Water bred	Malaria, Chikungunya, Filariases, Dengue
Water washed	Infections of the skin, infections of the eye
Water related	Drowning
WASH-related ailments reported in the NSS Survey	
Ailment	Reported Symptoms
Malaria	Fever with chills and rigors, profuse sweating, intense headache and presence of malarial parasite in the peripheral blood smear.
Filariasis	History of fever with unilateral/bilateral swelling of any limb/gland/scrotum confirmed by the presence of microfilaria in peripheral night blood smear or elephantiasis.
Jaundice	Presence of yellowish discoloration of eyes, passing high-colored urine, nausea, and itching.
Diarrhoea	Passage of 3 or more semisolid or liquid stools a day with/without fever/abdominal pain. Cholera, gastro-enteritis, dysentery.
Worms infestation	History of passing worms with stools or vomitus.
Undernutrition	When the child is very thin built, lethargic and the actual weight is less than weight for age/weight for height. Symptoms of vitamin deficiency including night blindness, lethargy, ulcers in the angles of the mouth, swelling feet with protuberant stomach.
Eye infection	Conjunctivitis/Corneal Ulcer/Iritis/Infection of eyelids or lacrimal glands/Foreign body in eye/trauma, redness of eyes with watering and foreign body sensation with/without discharge.
Skin infection	Characterized by presence of lesions – raised, rings, blisters, scales, discolored patches, itching, redness.

References

- State of the World's Sanitation. *An Urgent Call to Transform Sanitation for Better Health, Environments, Economies and Societies*. New York: United Nations Children's Fund (UNICEF) and the World Health Organization; 2020. <https://www.unwater.org/water-facts/water-sanitation-and-hygiene/>. Accessed June 1, 2021.
- Spears Dean, et al. Open defecation and childhood stunting in India: an ecological analysis of new data from 112 districts. *PLoS one*. 2013;8. <https://doi.org/10.1371/journal.pone.0073784>.
- Prüss-Ustün A, Bos R, Gore F, Bartra J. *Safe Water Better Health*. Geneva: World Health Organization; 2008.
- Global burden of 369 diseases and injuries in 204 countries and territories, 1999–2019: a systematic analysis for the Global burden of Disease Study. *Lancet*. 2019;396:1204–1222. [https://doi.org/10.1016/S0140-6736\(20\)30925-9](https://doi.org/10.1016/S0140-6736(20)30925-9).
- World Health Organization. Water, sanitation, hygiene and health: a primer for health professionals [Internet]. <https://apps.who.int/iris/handle/10665/330100>; 2019. Accessed June 1, 2021.
- CDC -Disease threats and global WASH killers [Internet]. <https://www.cdc.gov/healthywater/global/WASH.html>. Accessed May 20, 2021.
- WHO – UNICEF. Progress on sanitation and drinking-water - 2014 update. Geneva. In: *WHO and UNICEF Joint Monitoring Program on Water and Sanitation*; 2015 [Internet]. <https://apps.who.int/iris/handle/10665/112727>. Accessed May 20, 2021.
- From internet https://www.pmindia.gov.in/en/major_initiatives/swachh-bharat-abhiyan. Accessed May 25, 2021.
- Rural Sanitation Strategy 2019-2029, Department of Drinking Water and Sanitation, Ministry of Jal Shakti, Government of India.(n d).
- Institute for Health Metrics. Country profiles. <https://vizhub.healthdata.org/gbd-compare/india>. Accessed May 25, 2021.
- Causes of death statistics 2010-2013, office of the registrar general & census commissioner, India, Ministry of Home Affairs, Government of India https://censusindia.gov.in/vital_statistics/causesofdeath.html. Accessed May 25, 2021.
- National Health Profile. *Ministry of Health and Family Welfare*. Govt. of India; 2020.
- Hubbard SC, Meltzer MI, Kim S, et al. *Household Illness and Associated Water and Sanitation Factors in Peri-Urban Lusaka, Zambia, 2016–2017*. NPJ Clean Water; 2020; 3. <https://doi.org/10.1038/s41545-020-0076-4>, 26.
- Shrestha MV, Adhikari SR, et al. Household expenditure on diarrhea treatment among under five children in Godawari municipality of Nepal. *J. Nepal Health Res. Coun.* 2019;13;17(3):351–356. <https://doi.org/10.33314/jnhrc.v17i3.2181>.
- Paudel U, Pant KP. Estimation of household health cost and climate adaptation cost with its health related determinants: empirical evidences from western Nepal. *Heliyon*. 2020;6(11). <https://doi.org/10.1016/j.heliyon>.
- Rahman MM, Zhang C, et al. Disease-specific out-of-pocket healthcare expenditure in urban Bangladesh: a Bayesian analysis. *PLoS One*. 2020; Jan 14;(1):15. <https://doi.org/10.1371/journal.pone.0227565>.
- Harving ML, Rönsholt FF. The economic impact of dengue hemorrhagic fever on family level in Southern Vietnam. *Dan. Med. Bull.* 2007;54:170–172.
- Clark DV, Mammen Jr MP, et al. Economic impact of dengue fever/dengue hemorrhagic fever in Thailand at the family and population levels. *Am J Trop Med Hyg.* 2005;72:786–791.
- Kumar D, Garg S. Economic burden of dengue fever on households in Hisar district of Haryana stat, India. *Int. J. Adv. Med. Health Res.* 2014;1(2):99–101.
- Gupta I, Chowdhury S. Economic burden of malaria in India: the need for effective spending. *WHO South East Asia. J Public Health.* 2014 Jan-Mar;3(1):95–102. <https://doi.org/10.4103/2224-3151.206894>.
- Gopalan SS, Das A. Household economic impact of an emerging disease in terms of catastrophic out-of-pocket health care expenditure and loss of productivity: investigation of an outbreak of chikungunya in Orissa. India. *J. Vector Borne Dis.* 2009; Mar;46(1):57–64.
- Kastor A, Mohanty SK. Disease-specific out-of-pocket and catastrophic health expenditure on hospitalization in India: do Indian households face distress health financing? *PLoS One*. 2018; May 10;(5):13. <https://doi.org/10.1371/journal.pone.0196106>.
- Tripathy JP, Prasad BM. Cost of care and its impact on households due to lymphatic filariasis: analysis of a national sample survey in India. *J. Vector Borne Dis.* 2020; Jan-Mar;57(1):31–36. <https://doi.org/10.4103/0972-9062.308796>.
- National Sample Survey Organization (NSSO). Social consumption: health, NSSO 75th round (july 2017-june2018). In: *Ministry of Statistics and Program Implementation. Government of India*. New Delhi: National Sample Survey Organization; 2019. <http://mospi.nic.in/unit-level-data-report-nss-75th-round-july-2017-june-2018-schedule-25.0> Social-Consumption-Health. on 1/5/2021).
- Geruso, michael, and dean spears. Neighborhood Sanitation and Infant Mortality. National Bureau of Economic Research Working Paper. 2015 Series No. No. 21184.
- Duncan C, Jones K, Moon G. Context, composition and heterogeneity: using multilevel models in health research. *Soc Sci Med.* 1998 Jan;46(1):97–117.
- Rabe-Hesketh S, Skrondal A. *Multilevel and Longitudinal Modelling Using Stata*. College Station, TX: Stata Corporation; 2005.
- Choudhuri Pallavi, Desai Sonalde. Lack of access to clean fuel and piped water and children's educational outcomes in rural India. *World Dev.* 2021;145. <https://doi.org/10.1016/j.worlddev.2021.105535>. . Accessed August 21, 2021.
- [Internet] <https://jaljeevanmission.gov>. Accessed June 1, 2021.