Cross-sectional health indicator study of open defecation-free villages in Madhya Pradesh, India

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India's Total Sanitation Campaign (TSC), started in 1999, has the primary aim of 'eradicating the practice of open defecation by 2012'. This paper describes a cross-sectional health indicator study of four villages – two 'open-defecation free' (ODF) villages and two non-ODF villages) in Madhya Pradesh in 2006.

The study included:(a) an epidemiological investigation based on a study population of 1,245 individuals; (b) microbiological and parasitological examinations of 10 per cent of stool samples from study population; and (c) water quality and sanitary inspection analysis.

Results from the study indicate that both diarrhoeal morbidity and overall worm infestations from stool samples reduced in the ODF villages. Results however indicated high levels of microbiological contamination of the water supplies in ODF villages as well as an increased prevalence of hookworm infestation in 16 per cent of the population. These results reflect that, as revealed by interviews, despite improved latrine coverage, many ODF villages are still practising open field defecation resulting in the transmission of hookworms through the human–soil–human contamination route. The study concluded that, to maximize the health benefit of ODF, a choice of alternative sanitation technology options combined with appropriate hygiene promotion must be undertaken.

Keywords: open defecation, Total Sanitation Campaign, hookworm, ascaris, thermotolerant coliform, enterococcus faecalis

Since the work of John Snow in the United Kingdom in 1854, there have been numerous studies on the impact of water and sanitation and its associated impact on health in developing countries. These include work by Esrey et al. (1990, 1991) which concluded that latrine ownership could reduce diarrhoea incidence by 37 per cent, ascaris

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Latrine ownership could reduce diarrhoea incidence by 37 per cent

prevalence by 28 per cent and hookworm prevalence by 4 per cent. A further review by Fewtrell et al. (2005) investigated the impacts of sanitation, hygiene and water supply interventions and noted a significant correlation between water, sanitation and health.

Global statistics from the World Health Organization (WHO) estimate that, in 2007, 25 per cent of deaths in children and 6.3 per cent of deaths in adults still remain attributable to water, sanitation and hygiene-related diseases (WHO, 2007). In India, the WHO estimates that the environmental burden of disease associated with diarrhoeal disease results in 4,564,000 out of 10,378,000 deaths (WHO, 2007).

Indicator 31 of goal 7 of the Millennium Development Goals is to 'ensure environmental sustainability by halving the proportion of people without access to safe water and sanitation by 2015' (WHO/UNICEF, 2004). Goal 7 (and the subsequent International Year of Sanitation, IYS) were introduced to reduce the disease burden associated with poor access to water and sanitation. This is of significance in India, where, according to the UNICEF/WHO Joint Monitoring Programme Data (WHO/UNICEF, 2006), only 14 per cent of rural households in India had sanitation facilities in 2000 and 22 per cent in 2004. Following the launch of the Government of India Total Sanitation Campaign (TSC), this figure has been recorded to have increased to 33 per cent by 2006 and it is estimated by the Government of India that 100 per cent sanitation coverage will be achieved by 2017 (Alok, 2007). Under this scheme any village which achieves the target of 100 per cent sanitation is declared as 'Nirmal Gram-clean village' and a cash award is given to the respective Panchayat (group of villages) for the development of the village. This prize-based incentive scheme was initiated in 2003 and the definition of a 'Nirmal Gram-Clean Village' according to the Government of India is a 'fully sanitized and open defecation-free village' (DDWS, 2008). Specifically this would include: (1) 100 per cent sanitation coverage of individual households; (2) 100 per cent school sanitation coverage; (3) free from open defecation; and (4) clean environment maintenance (DDWS, 2008). Similar open defecation-free (ODF) criteria have applied in Indian states.

The 'Nirmal Gram' is a prize-based incentive scheme initiated in 2003 to promote clean villages

To date, no study has been done in India to study the impact of ODF on the health of the villagers. It is hypothesized that people living in the ODF villages will have reduced diarrhoeal-related morbidity and mortality compared with people living in non open defecation-free (NODF) villages. However, all exposure routes to the increased burden of disease must be considered (Lin et al., *2002*). This study therefore considers epidemiological, microbiological and parasitological indicators. The study was planned to study the prevalence of waterborne diseases in ODF villages and compare the data with NODF villages.

People living in ODF villages should have reduced diarrhoeal-related morbidity compared with others

Materials and methods

The study was undertaken in the central Indian state of Madhya Pradesh. A cross-sectional study was carried out to estimate the prevalence of various waterborne diseases.

Sample size

There were 1,250 individuals in the ODF villages and 1,100 individuals were present during the survey, of which 843 (76 per cent) were covered. Similarly in the NODF villages there were 1,000 individuals of which 800 were present during survey and 402 (50 per cent) willing individuals were covered. The coverage in the NODF villages was low as the villagers here were less cooperative as a result of the minimal government interventions in their village.

Inclusion criteria

A village which was declared as open defecation-free (ODF) at least one year prior to the survey by the MP state government was included as a study village as it was presumed that for sanitation to have an impact on health will require at least one year of open defecation-free environment. Any individual living in the village for more than a year who gave consent was included in the study. A neighbouring village with similar socio-economic conditions and population structure which was non open defecation-free was selected as a control (NODF) village. The socio-economic similarity was checked from the record of the local block development office.

For sanitation to have an impact on health might require at least one year of ODF environment

Any migrant who had moved to the villages within one year of the study was excluded.

Data collection

Sanitary inspection and groundwater readings were taken to calculate the risk of each of the water sources

Water quality/sanitary inspection survey. Twenty-one water samples were collected from ODF and NODF villages and analysed for microbial contamination. The indicator organisms analysed were thermotolerant coliform (TTC) and enterococci. Sanitary inspection and groundwater depth readings were taken to calculate the risk at each of the water sources.

Water samples were collected in pre-sterilized plastic bottles kept with ice packs at 4°C before analysis. Analysis of the thermotolerant coliforms and enterococci were performed using membrane filtration (Potaflex, portable water testing laboratory kit, WAGTECH). The samples were filtered through the Millipore 0.45μm nitrocellulose filter. For TTC membrane lauryl sulphate medium was used which was prepared with boiled de-ionized water. An aliquot of 2 ml of the solution was applied to each filter pad and incubated at an ambient temperature of 28°C for 4 h to permit the bacterial resuscitation, before being transferred to 44°C for 14 h incubation. After incubation, all the yellow convex shape colonies were recorded as TTC per 100 ml (Potaflex, portable water testing laboratory kit, WAGTECH).

Presumptive enterococci were isolated using azide nutri discs, pre-impregnated membranes with sodium azide. The samples were processed using membrane filtration, filter size being of 0.45 μm and applied to the azide nutri discs. A 4 h resuscitation period at ambient temperature was observed and then incubated at 44°C for 44 h. Although enterococci grow best at 37°C, they are less selective at this temperature than when incubated at 44°C. After incubation all red, maroon and pink bacterial colonies which were smooth and convex were identified and recorded as the presumptive enterococci per 100 ml (Godfrey et al., 2005).

The interviews on use, operation and maintenance of toilets were supported by community transect walks

Epidemiological survey: Data was collected by interviewing the head of the family using an interview schedule consisting of semi-structured questions regarding information on demographic and socio-economic factors. This interview included questions on use and operation and maintenance of toilets. These questions were supported by community transect walks.

After an informed consent a detailed clinical examination was carried out by medical officers to record various clinical signs and symptoms of current morbidity (within 7 days) especially waterborne diseases related to sanitation from every individual. For children below 18 years consent was obtained from the guardian. Past (three month recall method) history of waterborne diseases was also collected along with the severity and treatment taken for that episode of illness (Vinson et al., 2003). Three-month recall methods were used as earlier studies (RMRCT, 2004) carried out by the centre in the adjacent district revealed that the incidence of diarrhoea was 3.2 episodes per child per year. Hence on average in the three months (pre-monsoon period) preceding the survey they were likely to have had only one episode of diarrhoea, which is easy to recollect.

Anthropometric measurements (Rameshwar Sarma, 1998) such as height and weight of the preschool children were recorded.

Stool samples were examined for parasitic infestations

Parasitological survey. In 10 per cent of the willing individuals stool samples were collected in transport media and within 48 h the samples were brought to the laboratory for bacteriological culture (Mackie & McCartney's Practical Medical Microbiology, 1996) and microscopic examination for parasitic infestations (Soulsby, 1982). The flow diagram for laboratory diagnosis of enteric infections is outlined in Figure 1.

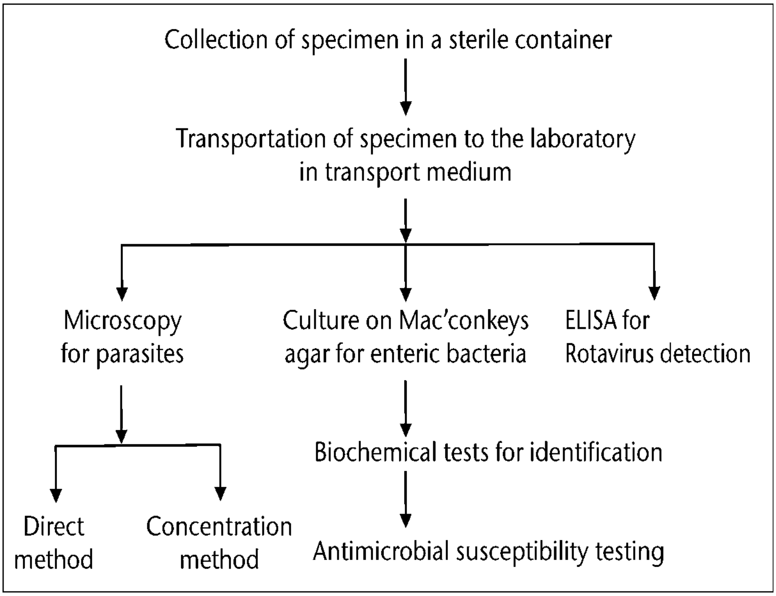

Figure 1. Flow diagram for laboratory diagnosis

Data analysis

Data collected was analysed using Epi info 2003 statistical package for epidemiological study, and water quality data was analysed to assess the microbial risk using SANMAN software.

Results

Water quality

Out of 21 water samples, 11 samples were collected from ODF and the remainder from the control villages (i.e. NODF villages). The sanitary risk was assessed for all the water sources. The concentrations of TTC and EF (*Enterococcus faecalis*) in different water sources of ODF and NODF villages are depicted in Figures 2 and 3.

From Figures 2 and 3 it can be observed that all the open wells are contaminated with TTC and EF above the WHO guideline value of <1cfu/100ml. Contamination levels of TTC and EF were higher in shallow dug wells than in boreholes owing to the shallow groundwater level. Low counts were noted as samples were taken in the pre-monsoon period when there is limited flushing of contaminants because of the lack of rainfall. Additionally, high levels of EF contamination were noted in the majority of sources owing to the high concentration of animals in the environment of the water source. To

Contamination levels were higher in shallow dug wells than in boreholes

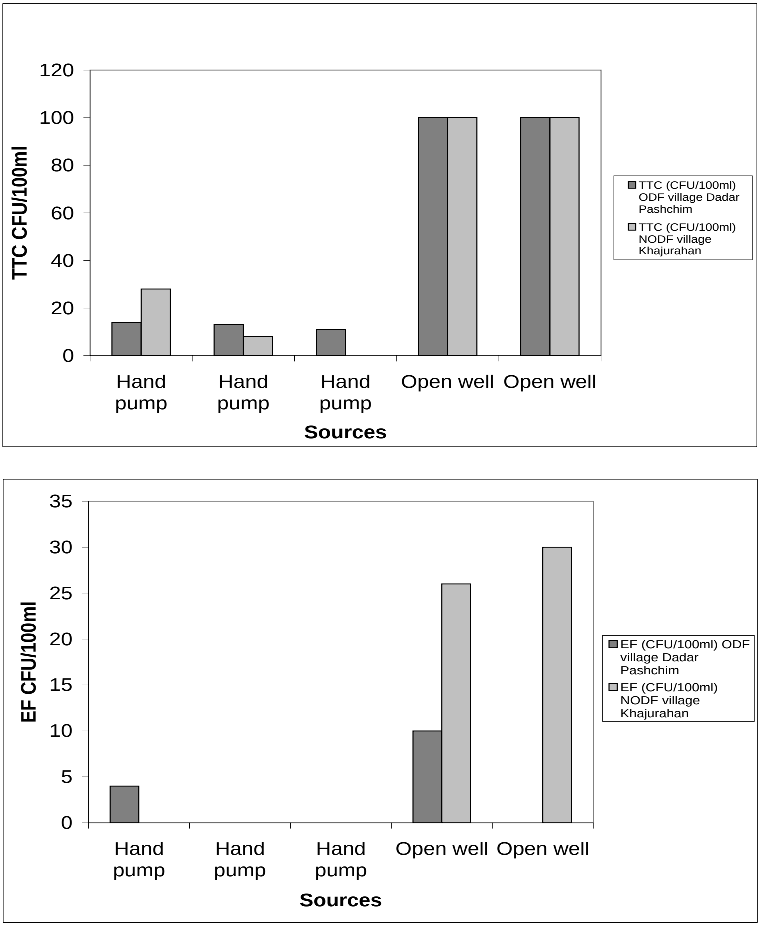

Figure 2. TTC and EF in water sources in Dadar Pashchim and Khajurahan.

gain a thorough understanding of the risk of contamination of the water source, results from the sanitary inspection indicated that in 100 per cent of water sources there was evidence of poor wastewater disposal around the wells as well as animal and human activity.

Sanitation

In the ODF villages 79 per cent of the individuals were using a sanitary latrine (Table 1). None of the individuals of the NODF villages was using a sanitary latrine. In-depth interviews with the ODF villages revealed that, because of the shortage of water, they are not all using the pour-flush sanitary toilets; instead some are still practising open field defecation (see later discussion).

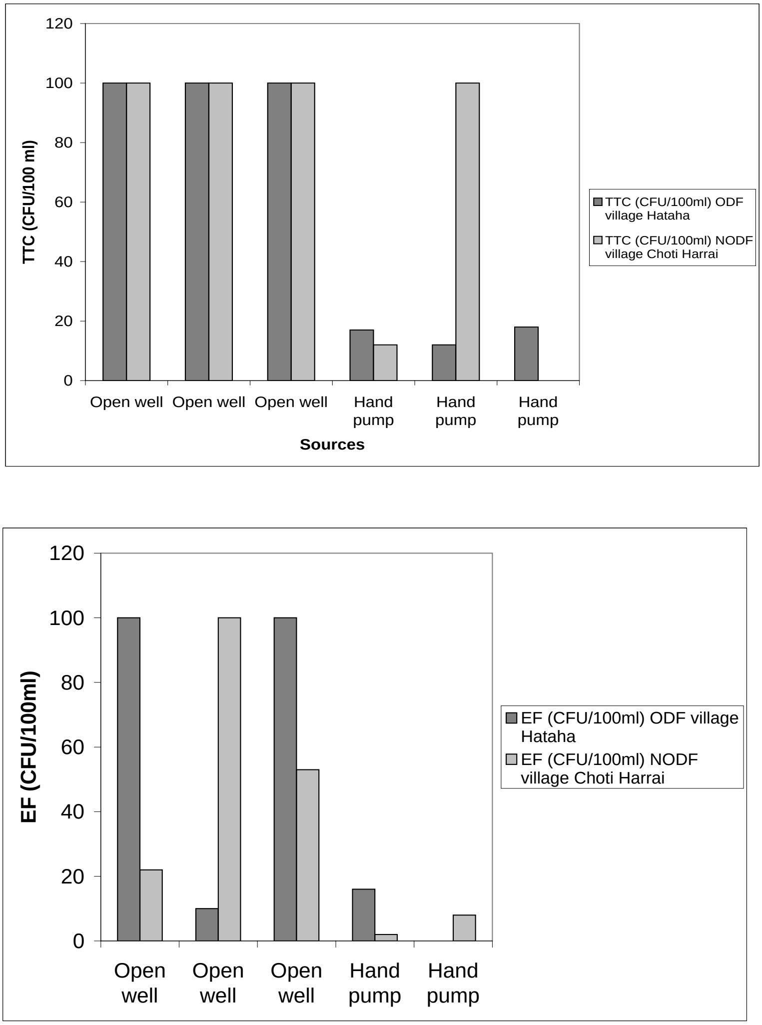

Figure 3. TTC and EF in water sources in Hataha and Choti Harrai.

Table 1. Percentage distribution of individuals using a sanitary latrine

Use of sanitary latrine	*Individuals from open defecation-free villages No. (%)*	*Individuals from non open defecation-free villages No. (%)*	*Total*
Yes	666(79.0)	0(0.0)	666(53.5)
No	177(21.0)	402(100.0)	579(46.5)
Total	843	402	1,245

Epidemiological study

A total of 1,245 individuals were studied of whom 843 were from ODF villages and 402 from the NODF villages from all age groups (Figure 4).

Diarrhoeal morbidity assessed through personal interview was significantly higher (five times) in the NODF villages compared with ODF villages in the three months preceding the survey. Prevalence of other morbidities such as fever and jaundice was also higher in NODF villages compared with the other ODF villages (Table 2).

Diarrhoeal disease was six times more common among individuals in the non-ODF villages compared with ODF villagers

Similar to the past morbidity, present morbidity also shows that diarrhoeal disease is six times more common among the individuals living in the NODF villages compared with the villagers of ODF (Table 3) villages.

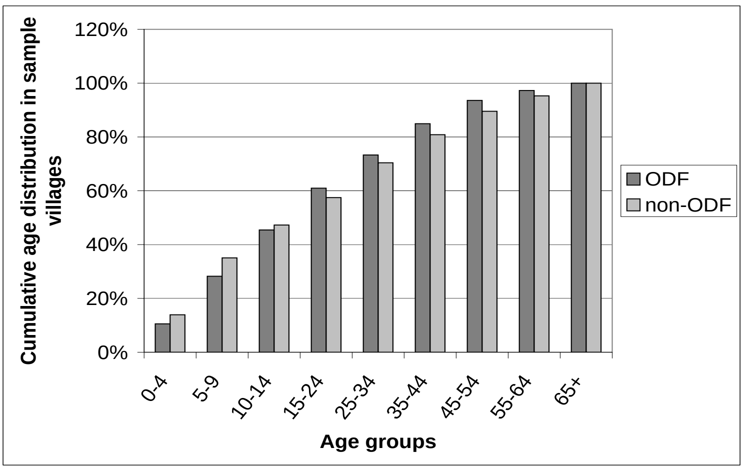

Figure 4. Age distribution of the study population in open defecation-free and non open defecation-free villages of Rewa, Madhya Pradesh, 2006

Table 2. Percentage distribution of past (last 3 months) diarrhoeal morbidity

Morbidity	*Open defecation-free villages No. (%)*	*Non open defecation-free villages No. (%)*	*Total No.*
Diarrhoeal disease	26/843 (3.08)[1]	60/402 (14.9)[1]	86
Jaundice	1/843 (0.11)	8/402 (1.99)	9
Fever	32/843 (3.79)	66/402 (16.4)	98
Other morbidity	14/843 (1.66)	35/402 (8.7)	49

[1]Statistically significant, two sample t-test between percentage -6.966, df-1243, $p<0.0001$

Table 3. Percentage distribution of present (within seven days preceding survey) diarrhoeal morbidity

Morbidity	*Open defecation-free villages No. (%)*	*Non open defecation-free villages No. (%)*	*Total No.*
Diarrhoea/dysentery	23/843 (2.72)[1]	64/402 (15.9)[1]	87
Jaundice	1/843 (0.11)	3/402 (0.74)	4
Fever	0/843 (0.0)	23/402 (5.7)	23

[1]Statistically significant, two sample t-test between percentage -8.536, df-1243, $p<0.0001$

Parasitological study

A total of 129 stool samples were taken to study the presence of various organisms in the stools. These included n=86 samples from ODF villages and n=43 from NODF villages (Table 4).

Bacteria. Escherichia coli was the commonest isolated organism and was detected in 32 per cent of stool samples in the individuals from NODF villages compared with 23 per cent of samples from ODF villages. However, we cannot state that they were all enteropathogenic as confirmation of all strains was not done. This was followed by Klebsiella and Campylobacter. It was noted that most of the organisms were sensitive to commonly used antibiotics such as Ciprofloxacin, Amikacin and Norfloxacin.

Virus. Rotavirus antigen detection was done using commercially available ELISA kits from RIDASCREEN (Rotavirus C 0901; R Bio Pharm AG, Darmstadt, Germany). Out of a total of 128 stool samples only three samples were found to be positive for rotavirus antigen, of which two were from ODF villages and one from an NODF village. Though rotavirus positivity was low, considering the time of sample collection (10–18 June) when temperature was above 40°C, this may be a warning signal.

Worm infestation was higher in the non-ODF villages than in the ODF villages

Parasites. Overall worm infestation was higher (44 per cent) in the NODF villages compared with 36 per cent in the ODF villages (Table 4). Hookworm infestation was the commonest in individuals of both ODF (16.3 per cent) and NODF (20.9 per cent) villages, followed by *Hymenolepis nana* (8.1 per cent and 13.9 per cent) and Ascaris (2.3 per cent and 6.9 per cent, respectively) (Table 4).

People living in 'ODF' villages were practising open defecation close to their home at night

These results reflect the fact that individuals living in ODF villages are practising open defecation close to their home at night due to fear/embarrassment of going out of the village for open defecation. This observation is supported by the data outlined in Table 1 which indicates that only 79 per cent of the latrines in the ODF village were recorded as used during a randomized unannounced community inspection. Of the remaining 21 per cent, findings from the community transect walk and the semi-structured interviews revealed the following.

All of the households quoted the lack of water as the reason for non toilet use

Lack of water. Under the Total Sanitation Campaign, the pour-flush toilet is the only recognized technology. The local government therefore promotes the technology regardless of its technological viability. All of the households not using their toilets quoted the lack of water as the reason for non toilet use.

Faeces around the household. The community transect walk revealed that open defecation was occurring around the households. Following further investigation during the semi-structured interview, the following quotes were obtained:

Mr Sukhdev, 40 years old, resident of Dadar Pashchim, one of the ODF villages stated: 'There is no hand pump in this part of the village. The nearest water source is about a kilometre from my house. In the day time we manage to go near the river to defecate. But at night we defecate near our house only.'

Similar views were expressed by Mr Durghatia, a 70-year-old neighbor of Sukhdev, who said 'it's not feasible to fetch one bucket of water from 1 km away just for flushing'.

Discussion

Despite a reduction in diarrhoeal disease there is still a significant percentage practising open defecation

The study of ODF and NODF villages indicates that there is a reduction in diarrhoeal disease in villages that are ODF. The results indicate that 23 per cent of the population suffered from diarrhoeal disease in ODF compared with 74 per cent in NODF. However, despite a reduction in diarrhoeal disease there is still a significant percentage (21 per cent) of the villagers in ODF villages who are practising open defecation despite mass awareness campaigns and awards. Furthermore, due to the potential 'shame factor' associated with open defecation

Table 4. Percentage distribution of parasitological diagnosis of stool samples

Category of villages	*Hookworm (Ankylostoma duodenale) No. (%)*	*H. nana (Hymenolepis nana) No. (%)*	*Round worm (Ascaris Lumbricoides) No. (%)*	*Thread worm (Enterobius vermicularis) No. (%)*	*Amoeba (Entamoeba histolytica) No. (%)*	*Mixed infection No. (%)*	*Total No. (%)*
Open defecation-free (n=86)	14 (16.3%)	7 (8.1%)	2 (2.3%)	5 (5.8%)	0 (0%)	3 (3.5%)	31 (36.0%)[1]
Non open defecation-free (n=43)	9 (20.9%)	6 (13.9%)	3 (6.9%)	0 (0%)	1 (2.3%)	0 (0%)	19 (44.2%)[1]
Total (n=129)	23 (17.8%)	13 (10.1%)	5 (3.9%)	5 (3.9%)	3 (2.3%)	1 (0.8%)	50 (38.7%)

[1]Statistically not significant, t-0.91, p>0.05.

in these ODF villages, it was observed that many of the 21 per cent are defecating during darkness (at night) close to their homes. This avoids them being humiliated for open defecation in the fields.

The past three months' diarrhoeal morbidity was higher in NODF villages compared with ODF villages. One of the reasons could be that the proportion of children under five years was greater in the NODF villages compared with the ODF villages (see Figure 4). Diarrhoea prevalence is known to be high in the under fives (Jones et al., 2006). However, owing to the small sample size, a conclusive statement cannot be made.

Consequently, hookworm infections are high in ODF villages where children walk barefoot around the house. The results also indicate that, despite a reduction in diarrhoeal disease, there is still contamination of drinking water sources (as indicated in the high prevalence of E. coli in stool samples as well as limited wastewater management).

Conclusions

ODF status results in reduced diarrhoeal disease

- ODF status results in reduced diarrhoeal disease in rural villages in Madhya Pradesh.
- ODF status reduced the overall prevalence of worm infestation among the individuals living in the ODF villages compared with the NODF villages.
- Alone, sanitation coverage may not improve the health of the villagers though it might have reduced the prevalence of diarrhoeal disease.
- The high percentage of hookworm infestation in ODF villages indicates that individuals living here are still practising indiscriminate open defecation close to houses at night and in the true sense these are not ODF villages.
- The health impact of ODF villages may be improved by expanding the sanitation technology available to the community by using a 'sanitation ladder'.

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