

A Randomized, Controlled Study of a Rural Sanitation Behavior Change Program in Madhya Pradesh, India

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Abstract

Poor sanitation and open defecation are thought to be a major cause of diarrhea and intestinal parasite infections among young children. In 1999, India launched the Total Sanitation Campaign with the goal of achieving universal toilet coverage in rural India by 2012. This paper reports on a cluster-randomized, controlled trial that was conducted in 80 rural villages in Madhya Pradesh to measure the effect of the program on toilet access, sanitation behavior, and child health outcomes. The study analyzed a random sample of 3,039 households and 5,206 children under five years of age. Field staff collected baseline measures of sanitation conditions, behavior, and child health, and re-visited households 21 months later. The analysis finds that implementation of the program activities was slower than the original timeline (only 35 percent of villages were triggered more than six months before the follow-up survey).

Nevertheless, the Total Sanitation Campaign successfully increased toilet coverage by 19 percent in intervention villages compared with control villages (41 percent v. 22 percent), while reported open defecation decreased by 10 percent among adults (74 percent v. 84 percent). The intervention also led to some improvements in water quality and protozoan infection, but consistent improvements were not observed across multiple child health outcomes (diarrhea, helminth infections, child growth). However, the exposure period was likely to have been too short to result in any benefit of the sanitation interventions on child health. Given the large improvements in toilet construction documented, an additional follow-up survey with a longer period of exposure would yield valuable information on the effects of improved sanitation conditions on health outcomes.

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1. Introduction

Open defecation is thought to be a major cause of the persistent worldwide burden of diarrhea and intestinal parasite infection among children < 5 years old [1]. Reducing open defecation requires access and use of improved sanitation facilities, which are defined as facilities that prevent human feces from re-entering the environment; in 2010, an estimated 47% of the world population did not have access to improved sanitation facilities [2]. India alone accounts for a quarter of the world's deaths from diarrheal diseases (387 million) [3], a third of those without improved sanitation (814 million) and nearly 60% of those who continue to practice open defecation (626 million)—the lowest rung on the sanitation ladder [2].

Observational studies of interventions that contain human feces and prevent them from entering the environment have been shown to reduce diarrheal disease [4,5] and intestinal parasite infections [6–8]. However, much of the research has focused on the provision of sewerage systems in urban centers, and to date there have been no published, randomized trials to measure the effect of sanitation provision on diarrheal disease or intestinal parasite infections in young children. Furthermore, in rural areas of low-income countries, the provision and maintenance of networked sewerage is usually prohibitively expensive in the short term. As a result, most government and donor financing in the rural sanitation sector has focused on the provision of non-networked toilets or latrines.

One approach to trigger large-scale toilet construction is Community-Led Total Sanitation (CLTS) [9]. Under CLTS, an external facilitator leads community exercises with the aim of changing community norms around open defecation. The activities highlight the magnitude of open defecation, they incorporate elements to elicit shame and disgust, and they attempt to mobilize community action for building toilets and leading the community to be “Open Defecation Free” (ODF). Facilitators encourage communities to come up with their own latrine designs that incorporate low cost, locally available materials. Individuals typically contribute their own time and materials to build toilets; for this reason, CLTS programs use relatively little public funds and rely heavily on private investment.

Since the early inception of CLTS in Bangladesh in the late 1990s, the practice has rapidly spread throughout the rest of Asia and Sub-Saharan Africa [9]. The Indian government launched the Total Sanitation Campaign (TSC) in 1999 with a goal of reaching universal rural sanitation coverage by 2012. India's TSC used principles of CLTS to motivate private toilet construction by attempting to change community norms around open defecation; TSC also provided financial incentives for local governments to achieve high levels of coverage, and subsidies for households to offset the capital costs of toilets.

In 2006, the World Bank's Water and Sanitation Program (WSP) launched the Global Scaling Up Rural Sanitation program⁷ to support local and national governments in India, Indonesia, and Tanzania to provide sanitation at scale. The program focused on learning how to combine the approaches of CLTS, behavior change communications, and social marketing of sanitation to generate sanitation demand and strengthen the supply of sanitation products and services at scale. In India, WSP supported efforts in rural Madhya Pradesh (MP) and Himachal Pradesh (HP) to strengthen TSC implementation.

WSP incorporated a cluster-randomized impact evaluation in Madhya Pradesh to gather rigorous evidence of the effectiveness of the TSC.⁸ The evaluation was designed to fill three research gaps in the rural sanitation sector that, if filled, would help guide future implementation practice: (1) lack of randomized evaluations; (2) lack of objective outcome measures (including health outcomes); and (3) lack of evaluations of large-scale programs. The objectives of the evaluation were to measure the effect of the TSC on toilet coverage, open defecation, water quality, and child health (diarrheal disease, intestinal parasite infections, anemia, and growth). We hypothesized that the program would increase toilet coverage and reduce open defecation. We further hypothesized that the program would improve water quality by reducing the quantity of feces in the environment that could contaminate shallow groundwater aquifers or water distribution networks. The reduced load of enteric pathogens in the environment may also reduce transmission through flies, which are well-established vectors for enteric pathogens [10–12]. Conditional on improvements in these intermediate outcomes, we hypothesized that children < 24 months at enrollment in intervention villages would have a lower prevalence of diarrhea, intestinal parasite infections, and anemia when measured after the intervention. Finally, we hypothesized that the program would improve average weight-for-age and height-for-age in these young children as a result of fewer symptomatic and asymptomatic enteric infections [13–17].

Our research contributes to a small body of literature on the effectiveness of community demand driven, large-scale sanitation programs. Despite widespread delivery of large-scale sanitation programs that incorporate CLTS-like approaches, we are aware of few published, independent evaluations of them. A randomized controlled trial of TSC in Orissa, India found that the program – a combination of CLTS tools for behavior change and hardware subsidies to poorer households – led to a 19 percentage point increase in toilet ownership (32% v. 13%) in 2006 after 5-7 months of implementation [18]. In Zimbabwe, an observational study of the Participatory Hygiene and Sanitation Transformation (PHAST) campaign that combined elements of CLTS with subsidized hardware increased toilet ownership from 2% to 43% [19]. In 2004, a CLTS campaign in Ethiopia that constructed over 89,000 latrines found that 87% of 160

⁷ For more information on Global Scaling Up Rural Sanitation, see www.wsp.org/scalingupsanitation.

⁸ The study was initially designed for two independent sites in Madhya Pradesh (MP) and in Himachal Pradesh (HP). Due to delays on baseline survey preparation and the impossibility to hold implementation in the control areas in the state of HP, it was decided that the final impact evaluation only included the state of MP.

randomly selected households had completed their latrines and that 90% (144/160) of the latrines were in use (the study provided no information about toilet coverage before and after the campaign) [20]. Taken together, these studies suggest that sanitation behavior change interventions result in toilet construction, but fall short of achieving “total” sanitation (or, 100% open defecation free communities). Two recent working papers that study India’s TSC have attributed large improvements in child height-for-age to the TSC. However, one study used administrative monitoring data collected by the project implementation teams which has been discredited due to vast over reporting compared to data from the recent census [43]. The second study from Maharashtra is a cluster-randomized trial [49]. While the study design is robust and the findings are important, the effects on height-for-age seem too large given the study included many children beyond the age of growth faltering (24 months) and only 8 percentage points in toilet construction [see 50]. Furthermore, there are no results published in peer reviewed journals on the health effects of TSC-style programs even though improved health has been a central benefit used to motivate the elimination of open defecation [22].

2. Background and Description of the Program

The government of India launched the Total Sanitation Campaign (TSC) in 1999, and at the time of this evaluation it was one of the largest rural development programs in India. The TSC included subsidies for and promotion of individual household latrines, school sanitation and hygiene education, Anganwadi⁹ toilets, and community sanitation complexes. The TSC also supported rural sanitary marts and production centers. The TSC included several unique features that distinguished it from earlier approaches to rural sanitation in India, including:

- A campaign-mode implementation approach
- A focus on demand generation through behavior change and communication campaigns
- A shift from high subsidy to low subsidy regimes
- A flexible menu of technology options
- An award, called the *Nirmal Gram Puraskar* (NGP), which is awarded to communities who are Open Defecation Free (ODF), defined as 100% of the population with access to a private- or shared toilet, and that meet all of the other total sanitation requirements. The award includes money and formal recognition to help incentivize entire communities.

TSC funding and program implementation was managed at the district level¹⁰ and program activities were implemented at the community (*Gram Panchayat*) level. Within each district,

⁹ *Anganwadi* – courtyard shelter in Hindi – is a child-care and mother-care center that is sponsored by the Indian government under integrated child development scheme (ICDS) program. These centers focus on children aged 0-6 years.

¹⁰ Indian administrative set up consists of central government, then state government, then districts, then blocks, then gram panchayats (GPs). Each GP consists of one or more villages. Within each village there can be one or more habitations or neighborhoods.

TSC implementation was coordinated within Blocks, which are one administrative level above individual communities. Block TSC offices coordinated latrine mason training, CLTS and social mobilization activities, and community outreach efforts. Block TSC offices also maintained official records of funds released to communities by the district, expenditures under the TSC, and toilet construction progress.

WSP's Scaling Up Rural Sanitation program in India supported the TSC program in two states: Himachal Pradesh and Madhya Pradesh. WSP supported local authorities in the creation of an enabling environment to facilitate TSC activities, the development of local capacities at the district level and the use of monitoring information to assess progress towards TSC goals.

In Madhya Pradesh, the department of rural development was responsible for implementing the TSC. A concurrent program in Madhya Pradesh named *Nirmal Vatika* ("Clean House" in Hindi) provided additional support in the form of household subsidies and toilet construction materials during the evaluation period. TSC and *Nirmal Vatika* together provided at least Rs 4200 (US \$80) to Below Poverty Line (BPL) households and at least Rs 2000 (US \$40) to non-BPL households to support toilet construction. These costs were determined by the government to be adequate to construct a single toilet with proper sub-structure including a slab and water seal, and a superstructure for the toilet. BPL households were expected to complete the superstructure or toilet room (4 walls, a roof and a door) using locally available materials. In addition, community level ODF awards (named *Nirmal Gram Puruskar*) are provided for GPs ranging from Rs 50,000 (US \$1,000) for GPs with populations ≤ 1000 to Rs 500,000 (US \$10,000) for GPs with populations of 10,000 or more. Awards for achieving ODF status were also given at the Block level (maximum award of Rs 2,000,000 or US \$40,000) and at the District level (maximum award of Rs 5,000,000 or US \$100,000). In addition to usual government efforts, WSP supported training for triggering activities in the 20 intervention GPs in each district to help build the capacity of local government staff and program volunteers.

3. Evaluation Design and Methodology

The evaluation used a cluster-randomized, controlled trial to evaluate the impacts of TSC in the Dhar and Khargone districts of MP. The study randomized communities within each district into two groups: an intervention group who received the TSC program and a control group who did not receive TSC activities until after the evaluation. The evaluation conducted household surveys to measure household and child characteristics both before and after TSC implementation.

3.1 Sample Size

The study was originally designed to have 80% power to detect a reduction in diarrhea prevalence among children < 5 years old of 4.5 percentage points assuming 15% prevalence in the control group (or a 30% relative reduction) with a two-sided alpha of 5%. This led to a

design with 40 clusters per arm and 25 households with children < 5 per years cluster. After the baseline survey, we decided to additionally power the study to detect differences between groups in height-for-age Z-scores based on a hypothesis published on the possible effects of improved hygiene and sanitation on child growth [15]. We reviewed measures of variability and within-cluster correlation of height-for-age Z-scores (SD=2.09, intra-class correlation=0.17), and chose to increase the within-cluster sample sizes from 25 to 38 households to ensure the study had 80% power to detect differences of +0.2 Z in height-for-age.

3.2 Sample Selection and Randomization

Village selection: Due to the large-scale implementation of TSC in Madhya Pradesh at the beginning of the study in 2009, we did not include a random sample of villages and instead enrolled villages in administrative areas that were willing to participate in the study. The evaluation selected *Gram Panchayats* (hereafter referred to as “villages”)¹¹ in three stages. First, the state government and WSP selected two districts out of the 50 in Madhya Pradesh – Dhar and Khargone – who were willing to work with WSP to implement the TSC. Second, the evaluation included 11 of 13 blocks from Dhar district and 8 of 9 blocks from Khargone; the remaining blocks were excluded from the evaluation because block officials were unwilling to maintain control villages for the length of the study. Third, in each block the government identified villages where they were indifferent about implementing the TSC program. We selected 40 villages in each district with between 2 and 8 villages from each block (larger blocks contributed more villages).

Household selection: In each selected village the field team listed and mapped 200 households and used systematic random sampling to select 25 households with at least 1 child < 24 months of age in the baseline. The field team focused survey efforts in the most populous parts of each village. We visited the same households again at follow-up, and expanded the study to include 38 households per cluster due to sample size considerations (described above). Because we conducted the follow-up survey 21 months after the baseline, the eligibility criteria for newly enrolled households was that they had at least one child between the ages of (0 + 21 =) 21 months and (24 + 21 =) 45 months and were living in the village at the time of the baseline survey to be commensurate with the eligibility criteria for the original cohort.

Randomization: The 80 study villages (*Gram Panchayats*) were the independent units and were randomly allocated in equal proportion to intervention or control. The randomization was stratified at the administrative block level. We stratified the randomization because TSC implementation was coordinated at the block level and we wanted to ensure that the treatment arms were evenly allocated between districts and geographically stratified within districts. The randomization took place in a public lottery in each of the 19 blocks. In each lottery, eligible

¹¹ A *Gram Panchayat* could include one large village or a group of villages; on average, a *Gram Panchayat* included 2 to 3 villages in the study region.

village names for a block were written in pieces of paper and the block TSC coordinator blindly selected half of the papers as intervention villages. Overall, we assigned a total of 20 villages in each district to the TSC intervention and 20 to control (40 villages per arm).

3.3 Outcome Measurement

The evaluation measured outcomes using a combination of survey questionnaires, field staff observations, environmental samples, child measurements, and specimen collection. Questionnaires used in the follow-up survey were the same as those used in the baseline survey with some additional questions to measure program exposure and program outcomes. The study collected the following sources of information.

Household Questionnaire: The household questionnaire collected information about household membership and demographics, income, assets, dwelling characteristics, TSC program exposure, water and sanitation infrastructure, sanitation- and hygiene-related behaviors, mortality, and exposure to health interventions. Interviewers conducted standardized observations of dwelling hygienic conditions and sanitation and handwashing facilities when visiting households.

Caregiver reported diarrhea: For children < 5 years old, field staff administered a health calendar to each child's primary caregiver, which was modeled on a previously published design [23]. The calendar measured daily symptoms back from the morning of the interview for 14 days (baseline survey) and 7 days (follow-up survey); the recall period was shortened for the second survey after we determined that recall errors were unacceptably large beyond 7 days [24]. We defined diarrhea as ≥ 3 loose or water stools in 24 hours, or a single stool with blood/mucus [25]. We additionally measured respiratory symptoms (cough, congestion, difficulty breathing) and child health symptoms not plausibly influenced by the TSC program (bruising/abrasions, itchy skin/scalp) to serve as negative control outcomes [26] because we were concerned that caregiver-reported symptoms could be subject to differential reporting bias in this unblinded trial [27,28].

Anthropometry: We measured eligible children for height, weight, and mid-upper arm circumference (MUAC) using a standardized anthropometry protocols [29,30]. Pairs of anthropometrists measured child length/height to the nearest 0.1 cm using a portable stadiometer (Seca); children < 24 months were measured in the recumbent (lying) position and older children were measured standing. Weight was measured to the nearest 0.1 kg using an electronic scale (Tanita); children unable to stand were weighed in their caregiver's arms and the caregiver's weight measured separately. MUAC was measured to the nearest 0.1 cm using a pediatric measuring tape. All measurements were collected in duplicate and we used the average of the two measurements in the analysis. We excluded observations if the two measurements differed by > 10% (N=21 for height, N=85 for weight, N=23 for MUAC). We translated the anthropometric measurements into Z-scores using the WHO 2006 growth standards and a publicly available Stata algorithm [31].

Anemia testing: If the caregiver provided informed consent, trained field staff cleaned a fingertip with disinfection liquid, and then collected a finger prick blood sample using a spring loaded, disposable lancet from children in study households between the ages of 6 and 60 months. A drop of blood was placed in a micro-cuvette, and the hemoglobin concentration was measured (HemoCue, HemoCue Ltd, Angelholm, Sweden) and reported to the caregiver. We classified children as severely anemic if their hemoglobin concentration was < 7.0 grams per deciliter (g/dl), moderately anemic if their hemoglobin concentration is 7.0 - 9.9 g/dl, and mildly anemic if their hemoglobin concentration is 10.0 - 11.9 g/dl [32]. Parents of children who were severely anemic were advised to visit the nearest health facility for medical attention.

Water Sample Collection and Analysis: Field staff collected 100 ml water samples from a random sample of approximately 400 households in each group to collect water samples from stored drinking water and from the household's designated water source. At the time of sample collection, field staff recorded information about the water source, storage and treatment (if any). Water samples were stored and transported in ice boxes for analysis within 24 hours to a field lab and tested for *E. coli* using membrane filtration within 36 hours of collection. The lower and upper limits of detection were 1 and 200 colony forming units (CFU) per 100 ml. Samples below the lower limited of detection were imputed at 0.5 (1/2 the limit of detection [33]), and samples beyond the upper limit of detection were imputed at the limit of detection (200).

Child Stool Collection and Analysis: At follow-up field staff collected stool from a random sample of 1,150 households (from an eligible list with replacement sampling) and collected stool from the youngest child over 21 months of age (<24 months at baseline). The field team left a user-friendly stool collection kit (sterilized spatula, paper, container) with the child's mother with verbal and written instructions on how to collect the samples. They advised mothers to note the consistency, color, and presence of blood in stool. The field staff then returned the following day to collect the stool samples. At the time of collection, field staff observed the sample for consistency and presence of blood, and added 10% formalin preservative. The preserved samples were stored in a shaded, cool and dry place and transported to the National Institute for Cholera and Enteric Diseases (NICED, Kolkata). NICED tested the samples within 30 days of collection for soil transmitted helminths (*Ascaris lumbricoides*, *Trichuris trichuria*, *Ancylostoma duodenale* and *Necator americanus*) and tapeworm helminths (*Hymenolepis nana*, *Taenia sp.*, *Diphyllobothrium latum*) using the Kato-Katz technique [34]. A separate aliquot was analyzed to determine the presence of protozoans (*Giardia lamblia*, *Cryptosporidium sp.*, *Entamoeba histolytica*) using a commercially available Enzyme-Linked Immunosorbent Assay (ELISA) kit (TechLab) [35,36]. If a child tested positive for one of the protozoan infections using ELISA, the result was confirmed using isolated DNA from the ELISA positive samples and PCR-restriction fragment length polymorphism (RFLP) methods for genotyping local isolates of *Giardia* (β -giardin) [37], *Cryptosporidium* (18s rRNA) [38], and *E. histolytica* (SSU rRNA) [39].

Community Questionnaire: The community questionnaire was administered at the village-level. We conducted surveys of the *Gram Panchayat* secretary (main administrative official),

elected head of the village, schools, Anganwadis, masons, and doctors (if available). Since our study sample was restricted to households with children < 24 months at enrollment, in the follow-up survey we added a rapid assessment from a random sample of households in the villages to measure sanitation coverage, quality of toilet construction, availability of hand washing place, type of drinking water source, and waste management practices.

Block Questionnaire: In each administrative block we conducted a survey to assess the inputs in TSC program in terms of finance, material, manpower and their associated cost. The purpose of this questionnaire was to conduct a detailed cost benefit analysis at a later stage (not included in this report) and to obtain official records of program implementation and status.

3.4 Field Implementation

Protocols and instruments used for data collection were designed by the WSP global impact evaluation team. These were revised, adapted, translated, and piloted by the India principal investigators. All data collection activities were conducted in Hindi. Study protocols and instruments are available from the corresponding author upon request. GfK Mode, Ltd. was contracted to conduct the fieldwork. The baseline survey was conducted between May and July, 2009, and the follow-up survey was conducted between February and April, 2011. The follow-up survey was conducted in a slightly different season due to concerns that the TSC program would soon expand into control villages. The India principal investigators, global team experts and GfK Mode researchers trained the field teams. Six field teams, each with four interviewers, 2 anthropometrists, 1 microbiology sampler, 2 supervisors, and one editor conducted the fieldwork at follow-up. Two field executives and one field coordinator handled oversight of the work in Madhya Pradesh.

3.5 Statistical Analysis

We compared the baseline characteristics of the randomized treatment groups to determine if any observed characteristics were imbalanced by chance despite randomization. Due to highly comparable groups at baseline and the large increase in our within-cluster sample between baseline and follow-up, our analysis focused on group comparisons post-intervention (using follow-up measures only). To evaluate the potential for attrition (loss to follow-up) between baseline and follow-up to bias our estimates, we compared baseline characteristics of those present at follow-up with those lost to follow-up; we also compared the balance of baseline characteristics across treatment groups for individuals who were present at both baseline and follow-up to determine whether attrition was differential by treatment group.

Our parameter of interest for all outcomes was the mean difference between randomized groups and we conducted the analysis using individuals as they were randomized (Intention to Treat; ITT). We estimated differences between groups using the following linear regression model:

$$Y_{ijk} = \alpha + \beta T_j + \delta X_{ij} + b_k + \varepsilon_{ijk} \quad (1)$$

Where, Y_{ijk} is the outcome for individual i in village j and block k , T_j is the intervention indicator (1 for intervention, 0 for control); X_{ij} are individual and cluster level characteristics used in adjusted analyses; b_k are indicator variables for block since randomization was stratified at the block level; and ε_{ijk} is the error term. The parameter β estimates the ITT difference between randomized treatment groups. In adjusted analyses, we included the following covariates to improve precision: whether the household head had attended school, whether the household belonged to a Scheduled Caste or Tribe (SCST), child age, child sex. Additionally, the adjusted models included any baseline characteristics found to be imbalanced between randomized groups.

To further assess differential impacts of the program by important population subgroups, we re-estimated the effect of the intervention for households with and without a toilet at baseline, and households above and below the official poverty line. Since we would expect behavior and child health outcomes to be correlated within villages, all estimates used Huber-White robust standard errors clustered at the village level [40]. We did not adjust P -values for multiple comparisons.

4. Results

4.1 Enrollment, Baseline Balance, and Attrition

Table 1 lists the number of households in each district and block at the baseline and follow-up in intervention and control groups as well as the percentage attrition in the sample. At baseline the evaluation enrolled 1,954 households and 3,390 children < 5 y in 80 villages with complete interviews. Of the 1,954 households enrolled, 1,655 were located at the 21-month follow-up measurement (15% attrition). There was no significant difference in attrition rates between the intervention (16%) and control (15%) groups. At follow-up, the study enrolled an additional 1,384 randomly sampled households that met the original enrollment criteria. Thus, the follow-up sample included 3,039 households and 5,209 children < 5 y in the final analysis.

Table 2 summarizes baseline household and child characteristics by randomized group. With few exceptions, randomization balanced the groups well with respect to measurable characteristics. However, there were a few important imbalances that are worth noting. First, 89% of the households in the intervention group had access to JMP improved water sources compared to 80% of households in the control group. In contrast, a larger fraction of control households had soap and water at handwashing locations used after defecation than in intervention households (44% v. 54% for intervention and control). On average, more children were found to be anemic in control group than the treatment (88% v. 93% for intervention and control, but this

difference is unreliable because of measurement errors ¹²) and the Z-score for height-for-age was also imbalanced (-1.38 v. -1.81 for intervention and control). Given these baseline differences between groups in access to JMP-defined improved water sources, handwashing conditions, and Z-score for height-for-age, we included the baseline village-level averages of these variables as covariates in adjusted models.

The internal validity of a longitudinal or panel study relies on maintaining low attrition during the follow-up period. In our study 15% (299 of 1,954) of the baseline households were not located in the follow-up for reasons of permanent migration, seasonal migration, and inability to find a household after repeated visits. This 15% attrition rate was not large enough to affect the power of our estimates. Of 299 households, 154 were in the intervention group and 145 were in the control group. Temporary or seasonal migration accounted for 81 percent of the lost households, which indicates that lost households may be economically different than those that remained in the study. Table 3 compares characteristics between intervention and control groups for the household samples that is lost at follow-up and that remains intact during follow-up survey. The attrition was not differential by randomized treatment group based on observable characteristics (Table 3). Characteristics remained balanced between intervention and control groups in intact households similar to those noted in Table 2.

4.2 Implementation and Exposure to TSC Activities

Implementation of TSC is carried out by local governments. Assessing and documenting TSC activities is challenging in the absence of a robust monitoring system for TSC. A comparison of official TSC data with recent figures from the Census suggests that official information consistently overestimates toilet construction coverage¹³. In India, toilet construction triggers the release of TSC funds for the subsidies that the government provides to below poverty line (BPL) households. The existing system tracks the funds released and utilized at different levels and toilet construction coverage as reported by the GP secretary. The monitoring system does not track project inputs in terms of behavior change or social mobilization efforts which are key components of TSC. Even the reported toilet construction levels are not objective and validated measurements.

We explored a variety of sources to assess the extent to which activities have been conducted and beneficiaries report being exposed to the TSC. First, we conducted a survey of TSC coordinators at the block level to assess TSC activities. The TSC coordinator is the official

¹² In baseline anemia was tested with children under 2 years but over 6 months of age. Due to high heat during summer months the Hemocue machines malfunctioned. We were able to collect data from only 27 out of 40 GPs and 329 children from the control group, and from 24 GPs out of 40 and 293 children from the intervention group. This high level of data loss and unreliability of hemocue measurements in high temperature reduces our confidence on the results presented, especially when the statistical significance level is $\alpha = 0.1$.

¹³ In MP, 86.9% of rural households still lack a toilet; a negligible improvement from 91.1% households without toilet as per 2001 census. As per TSC M&E records; however, almost 82% of the target households who lacked toilet in 2003 baseline are now provided an individual household latrine (IHL).

responsible to maintain records of TSC related activities. Second, to assess recollection of TSC activities and exposure to tools and information related to TSC, we surveyed *Gram Panchayat* (village) GP secretaries, school teachers, and *Anganwadi* (health centres) workers in the village, as well as a random sample of households in each village. This village survey selected randomly 40 to 80 households from each village (depending on its size) for a rapid questionnaire to assess their sanitation conditions.¹⁴

The information provided by TSC Block coordinator and GP secretary indicate that implementation of TSC activities was far slower than the original timeline. The program originally envisioned that implementation would be completed 18 months after our baseline survey. However, as depicted in Figure 2, TSC coordinators reported that social mobilization and behavior change activities were being carried out even close to the follow-up survey at 21 months. Figure 2 summarizes the timeline of the *latest* CLTS triggering relative the follow-up survey based on information for 39 of the 40 intervention villages from the block coordinators (we were unable to complete a coordinator interview in 1 village). We found that 35% (14/40) of villages were triggered >6 months before the follow-up survey, but that 50% (20/40) were triggered 1 month before the follow-up survey or later. It is possible that the villages were triggered multiple times in the past, but the survey could not capture retrospectively a complete record of TSC activities in the village.

Block coordinators were also asked to give an estimate of when they *believe* the intervention village would become ODF, which is summarized in Figure 3. For 63% (25/40) of intervention villages, the block coordinators estimated the villages would become ODF 6-months or longer after the follow-up survey. Table 4 provides additional results from the block coordinator interviews. We found that the most recent TSC-related activities were carried out after, during, or 1-3 months prior to follow-up survey in February 2011. Post-triggering follow-up visits to the village were reported in 11 of the 40 intervention villages at the time of our follow-up survey. While block coordinator interviews also identified that the behavior change aspects of TSC were being implemented, their official records indicated that the villages were close to having 100% toilet construction coverage as reported in Table 4. Official records of toilet construction would be indicative of the pace at which TSC funds were available and released to the local government authorities.

On the other hand, the information from additional sources (GP secretaries, school teachers, *Anganwadi* workers in the village, and the rapid assessment from random sample of households) confirmed that TSC activities translated in a higher recollection and knowledge of TSC in the intervention areas compared to the control. Results from these additional sources are summarized in Table 5.

¹⁴ Note that unlike the main household survey, this sample was not restricted to households with children < 24 months at enrollment; it is thus more representative of the village conditions as a whole.

According to village secretary interviews, villages in the Dhar district had higher levels of exposure to CLTS activities and study villages reported higher levels of implementation using funds from TSC or *Nirmal Vatika*. According to information collected from school teachers, the schools in the treatment areas were exposed to more CLTS tools and there was a substantial increase in school toilet coverage in comparison to control villages (67% v. 47%). Anganwadi workers in both districts are almost similarly exposed to CLTS tools with statistically significant higher exposure in intervention villages.

Across a broad set of measures we found that households in intervention villages were more aware of CLTS triggering, had higher knowledge of TSC, and experienced more personal visits to convince them to build and use toilets (Table 7, Panel 1). The percentage of households reporting that they changed their sanitation behavior as a result of personal visits was higher in the intervention group (15%) than in the control group (6%).

The rapid household survey of the entire village indicated that while awareness of TSC was similar in intervention and control villages, 36% of households in intervention villages versus 20% of household in control villages had a usable toilet. Furthermore, an additional 19% of households in intervention villages had toilet under construction versus just 7% in control villages. Our estimates of household toilet coverage are much lower than the official TSC statistics of 47% to 97% toilet coverage in intervention villages as maintained by the block coordinator.

In the main household survey (households with children < 24 months at enrollment), we found that the households in intervention villages in both districts had better exposure in terms of personal visits to promote sanitation, self reported change in sanitation related behavior following personal visits, and exposure to CLTS triggering tools, but the toilet construction levels were dramatically lower than official records (Table 5).

Although the 21-month follow-up survey closely followed implementation activities in some intervention villages, the evaluation faced the risk of contamination of control villages. Prior to planning the follow-up survey, the discussions with the project implementation staff confirmed TSC related activities had started in 10 of the 40 control villages.¹⁵ In addition, the government announced the roll out of activities in the remaining TSC control villages within few months of the planned follow-up survey. The objective of the evaluation was re-aligned to focus on immediate impacts of TSC as opposed to longer term impacts that could be expected after a longer program exposure (e.g., child development outcomes).

Taken together, the information from block coordinator surveys and exposure to TSC related activities measured at the village shows clear evidence of more social mobilization and behavior change activities as well as toilet construction in intervention villages compared to control

¹⁵ Activities were starting in 10 control villages: Kharadi, Ladvi, Aasngaon, Bagfal, Umari (Khargone District) and Mourad, Bhil Barkheda, Kuradiya, Marol, Bajattakhurd (Dhar district).

villages, although some social mobilization and behavior changes were ongoing more recently than anticipated.

In what follows we present the effects of the different exposure to TSC between treatment and control areas on outputs and intermediate outcomes along the value chain. We present some analysis by subgroups of interest and we finalize with a discussion of main findings.

4.3 Toilet Construction, Sanitation Behavior, and Health Outcomes

Secular Changes from Baseline to Follow-up (Table 6)

Table 6 includes means of key variables between follow-up and baseline in the intervention and control groups. Between baseline and follow-up surveys, the household demographic and economic variables have remained stable. Household access to JMP improved water sources was nearly universal at follow-up in intervention (97%) and control (95%) villages, and water quality, measured by *E. coli* indicator bacteria in stored drinking water, also improved over time in both groups. Diarrhea prevalence was lower at follow-up in both groups in part because of the aging cohort and possibly because the follow-up survey took place in a different season than baseline.

Toilet Coverage and Sanitation-related Behavior (Table 7, Panel 2)

The TSC program increased JMP improved toilet coverage by 19 percentage points in intervention villages compared to control villages (41% v. 22%). At follow-up, JMP improved toilet coverage in the intervention villages ranged from 5% to 79% (median 42%, IQR 27%, 57%), and in control villages it ranged from 0% to 74% (median 26%, IQR 5%, 36%). Although fewer households in intervention villages were likely to report daily open defecation compared to control villages for adult men (73% v. 83%), adult women (74% v. 84%), and children < 5 y (84% v. 89%), these reductions in reported OD behavior were smaller than the gains in improved toilet coverage. For example, although treatment groups reports lower OD levels, overall levels remain high (73% for adult men). Among the 630 households in intervention villages that had a JMP improved toilet at follow-up, 41% reported that adult men still practiced daily OD and 64% reported that children < 5 years practiced daily OD. Among 339 control village households with a JMP improved toilet at follow-up, 32% reported that adult men practiced daily OD and 54% reported that children < 5 years practiced daily OD. Although OD behavior remained prevalent among young children in both groups, households in intervention villages were more likely to report proper disposal of child feces based on the JMP definition (27% v. 18%). We observed no difference between groups in the proportion of households with no human or animal feces observed in their living area around the structure (40% in both groups).

Drinking Water Quality (Table 7, Panel 3)

Drinking water quality was poor in the study population. In control villages, 82% (331/403) of household drinking water samples tested positive for *E. coli*; water quality was slightly improved in intervention households where 77% (310/404) of samples tested positive for *E. coli*.

Intervention households also had slightly lower concentrations of *E. coli* than control households based on quantitative measures (1.25 vs 1.40 log₁₀ *E. coli* CFU per 100 ml). Of 514 village source samples tested, 74% (210/282) of the sources in control villages and 70% (163/232) in intervention villages tested positive for *E. coli*. The results are statistically not significant in the “adjusted” model.

Intestinal Parasite Infections (Table 7, Panel 4)

In the subsample of 1,150 children who provided stool specimens, 5.7% (66) had some helminth infection and the majority of the infections (50/66) were *Ascaris*. Besides *Ascaris*, all remaining infections were tapeworms; no children were infected with *Trichuris* or hookworm. We observed no difference in helminth prevalence between intervention and control groups.

Giardia infection was common, and consistent with slightly improved water quality in the intervention group, we observed lower *Giardia* prevalence among children in intervention villages (18%) compared to children in control villages (23%). However, in the adjusted model, while the direction of effect is the same the difference between intervention and control villages is not statistically significant. We observed no *Cryptosporidium* infections in the study children, and a low prevalence of *E. histolytica* (33 out of 1150; 2.9%). All specimens that tested positive for a protozoan infection using ELISA were confirmed as positive by the PCR assays (there were no false positives).

Caregiver Reported Illness (Table 7, Panel 5)

Diarrhea prevalence did not differ between intervention and control groups (8%), and acute respiratory illness was more prevalent in the intervention group than in the control group (17% v. 13%). We observed no significant differences between groups in negative control caregiver-reported outcomes including bruising/abrasions (1.4% v. 1.3%) and itchy skin/scalp (2.5% v. 2.2%) suggesting that a positive response bias was less likely.

Anemia and Anthropometry (Table 7, Panel 6)

Anemia was prevalent (54%) in the study children, and children were also small based on international growth standards. For example, mean weight-for-age Z-scores were –1.83 (control) and –1.92 (intervention), and mean length-for-age Z-scores were –2.16 (control) and –2.19 (intervention). We observed no differences between groups in anemia prevalence or most anthropometric measurements.

4.4 Subgroup Results

Table 8 presents the results of subgroup analyses of the TSC program impacts. We found that overall the program impacts on toilet construction, use of toilet, and reduction in open defecation were concentrated in households that did not have a toilet at baseline and those that were Below Poverty Line (BPL). For example, among BPL households, the intervention increased JMP improved toilet coverage by 32 percentage points compared to control (49% v. 17%) and it reduced open defecation among women by 21 percentage points (71% v. 92%).

Despite larger improvements in toilet construction and open defecation practices among BPL households or those with no toilet at baseline, we did not observe consistently larger improvements in child health in those subgroups. Instead, we observed larger reductions in diarrhea and *Giardia* among households who had a toilet at baseline, yet in this subgroup the intervention did not increase toilet construction, toilet use, or reduce open defecation. This suggests that the differences in child health could be due to chance given the small size of the subgroup (<100 individuals per arm) and the large number of subgroup comparisons made.

Discussion

Summary of Main Results

This 80-village study conducted in rural Madhya Pradesh represents the one of the first large-scale, randomized evaluations of India's Total Sanitation Campaign (TSC) to include child health measurement. Based on the latest reported CLTS triggering activity in each village, the program was not implemented to its full extent at the time of the follow-up survey (only 14 of 40 intervention villages had > 6 months of exposure). However, the information from other sources and especially the exposure to TSC related activities measured at the village level shows clear evidence of more social mobilization and behavior change activities as well as toilet construction in intervention villages compared to control villages. We observed as well some evidence for contamination in 10 of 40 control villages close to our follow-up survey. The incomplete program delivery and slight contamination of the control group would in theory bias our findings towards an underestimate of program impact.

Despite the absence of full exposure to the program at the time of our follow-up measurement, we found that the TSC increased toilet coverage by 19 percentage points in intervention villages compared to control (41% v. 22%). Improvements in sanitation-related behavior were more modest: reported open defecation among adults decreased by 10 percentage points (e.g., 73% v. 83% among women) and correct child feces disposal increased by 9 percentage points (27% v. 18%). Among households in the intervention arm with a JMP improved toilet, 41% reported that adults still practiced daily OD. We found that program impacts on toilet coverage and sanitation-related behavior were concentrated almost entirely among households without a toilet at baseline and households that were below the poverty line, which is consistent with the program design that provided higher amounts of subsidies to such households. Reduced levels of *E. coli* in intervention household drinking water and lower *Giardia* prevalence in intervention children are consistent with the possibility that the TSC program reduced waterborne transmission of this pathogen in intervention villages. However, we found no evidence for reductions in helminth infection or diarrheal disease, and no evidence for more distal impacts on anemia or growth during the study period.

Interpretation

Many child health studies of water, sanitation, and hygiene interventions have been small-scale, short-duration efficacy trials [41]; these trials are an essential step in documenting the potential for interventions to impact child health, but ultimately the external validity of such studies remains open to debate. This study was designed to measure the impacts of one of the largest public health interventions in human history: India's TSC has touched the majority of rural Indian households since its inception in 1999. Effectiveness studies that measure the impact of large-scale government programs face numerous challenges compared to tightly controlled efficacy trials. A central challenge is ensuring good compliance and high fidelity of intervention implementation. In this study, we found evidence of TSC activities in 10 of 40 control villages, and in no case did intervention villages achieve "Open Defecation Free" status. Although a finding of incomplete implementation is an important finding in itself, ITT estimates of program impacts with imperfect compliance will tend to underestimate the effect possible under perfect compliance. If the effects of rural toilet promotion campaigns are heterogeneous with village-level toilet coverage, then this study provides information only about conditions where toilet coverage is < 80% (with most villages closer to 40%). In theory, the effects of similar interventions on child health could be larger if intervention campaigns achieve higher levels of toilet coverage, but the question can only be answered empirically in future studies that achieve higher levels of toilet coverage in intervention villages and allow for a longer duration of program exposure.

A second challenge in studying large-scale programs that are not implemented by evaluation investigators is that implementation timelines may differ greatly from the original evaluation timeline. The follow-up measurement in this study (21 months following baseline) was the latest possible point we could measure outcomes under the grant timeline and our expectation that the program would soon expand into control villages. Although it is possible that impacts on diarrheal disease could begin relatively soon after intervention, as documented in short-duration efficacy trials [41], we would expect impacts on intestinal parasite infection and growth to potentially accrue more slowly. *Ascaris* ova are viable in the environment for many months (possibly years) [42]; for this reason, the hygienic disposal of feces may require many months to measurably reduce the quantity of viable helminth eggs in the village environment and subsequent parasite infection. Similarly, we would expect any benefit of sanitation interventions to child height to require many months of exposure to improved conditions since the causal mechanism is thought to work through a cumulative reduction of symptomatic and asymptomatic infections over the first years of life [13,43]. Given the large improvements in toilet construction documented in this study, an additional child health follow-up measurement in the study villages would yield valuable information over a longer period of exposure to improved sanitation conditions.

To provide some context to our results, we reviewed findings from recent studies of similar sanitation programs. Our findings contrast with the preliminary results reported in two working

papers that study India's TSC, both of which have attributed large improvements in child height-for-age to the TSC, and a third working paper that evaluated a large-scale sanitation program in Indonesia. Spears [44] estimated that children living in districts with an average level of TSC implementation had improved height of +0.2 Z-scores and reduced infant mortality by 4 per 1000. This study used administrative monitoring data collected by the TSC to measure program exposure combined with national surveys for child outcome measurements. However, official TSC monitoring data likely overstates actual implementation conditions. For example, in this study the TSC block coordinators reported that village level toilet coverage ranged from 47% to 97% in intervention villages, whereas village level toilet coverage in our study population ranged from 5% to 79% (median 42%). Correlated measurement errors in exposures or confounders usually lead to unpredictable biases that are often non-conservative [44–48].

In a second study from Maharashtra, Hammer and Spears [45] report results from a cluster-randomized trial that evaluated the TSC and was similar in design to the present study. Sixty villages were randomized to control or intervention in February 2004, and outcomes measured in August of 2004 and 2005. At the final measurement, the study reported a modest improvement of 8 percentage points in toilet construction but a strong increase of +0.4 Z in height-for-age among children < 5 years. The effects of the TSC on height-for-age are greater in magnitude than most complementary feeding efficacy trials in infants (mean +0.28 Z, range -0.04, 0.69) and far greater than effects observed in complementary feeding effectiveness trials [46,47]. While the study design is robust and the findings are important, the large effects on height-for-age just 6 months after enrollment when most children are beyond the primary window for growth faltering (0-24 months) [48] will need further research to determine whether the results are biologically plausible.

A companion study to the current evaluation was conducted in East Java, Indonesia [21]. Consistent with our results, the intervention in Indonesia significantly increased toilet installation and reduced open defecation, albeit at rates lower than in this study. Among households with no toilet at baseline (N=941), the Indonesia study documented a small but significant improvement in health outcomes including diarrhea, helminth infection, and anthropometry. However, these results while promising should be viewed with caution as this subsample is small and the experiment was not designed nor powered to examine health impacts in subsamples.

Our findings are broadly consistent with several recent studies of sanitation promotion interventions in South Asia. An earlier randomized evaluation in Orissa, India, between 2005 and 2006 randomly allocated the TSC program to 20 villages (20 reserved as control), and documented a 19-percentage point increase in household toilet ownership 5-7 months after implementation; the investigators found that a significant share of households were in the process of building their toilets, and suggested that later measurement would be helpful to document the full impact of the program. The findings from the present study are also consistent with results from an evaluation of the Sanitation Hygiene Education and Water supply in Bangladesh (SHEWA-B) [49]. The SHEWA-B project had the goal of improving sanitation,

hygiene, and water supply for more than 20 million rural Bangladeshis; a matched cohort study in 100 villages found modest improvements in implementation and behavioral outcomes, but no impact on child diarrhea after 2 years of intervention [49]. Arnold *et al.* [50] documented large improvements in toilet coverage, smaller improvements in open defecation, no improvements in diarrheal disease or height-for-age Z-scores in a matched cohort study of combined sanitation, water, and hygiene interventions in Tamil Nadu, India (a pilot implementation of TSC). A similar percentage of households with toilets reported adult daily OD in the Tamil Nadu study (39%) as in this study (41%), despite implementation being complete for more than 23 months in most intervention villages in Tamil Nadu. The toilet coverage and open defecation levels in the Tamil Nadu study were similar to those we observed in Madhya Pradesh, however diarrhea prevalence was much lower in Tamil Nadu (1.8%) and the authors inferred that open defecation was unlikely to be an important source of diarrheal pathogen transmission for children during their study. Although the findings from the present study are consistent with the hypothesis that open defecation may not be important source of diarrheal pathogen transmission for young children, we did not collect extensive information to confirm or rule out all transmission pathways.

We would expect the TSC program to reduce child exposure to fecal pathogens through two main environmentally mediated pathways (Figure 1): (i) reduced open defecation of sick adults and older siblings or other children in the household compounds where young children may encounter feces, and (ii) reduced contamination of village drinking water supplies by fecal transport through the environment. Intervention households were more likely to report hygienic methods of child feces disposal than control villages (27% v. 18%), but there was no difference in the absence of human or animal feces observed during household visits (40% in both groups) and we did not observe lower prevalence of *Ascaris* infections (Table 7). This suggests that the program did not successfully reduce pathogen transmission to children through soil. However, lower levels of *E. coli* in drinking water and lower *Giardia* prevalence in intervention villages compared to control villages provides some objective evidence to suggest that the TSC program may have reduced waterborne pathogen transmission. In the study population, 43% of households used bore wells that draw water from shallow groundwater aquifers that could be contaminated with feces, and 33% used piped water that can be cross-contaminated with sewage and run off due to negative pressure in the pipes during non-supply hours. *Giardia* may have proven to be a more sensitive measure of child health impact compared to diarrhea because it was more prevalent in this study population (Table 7) and it is more specific to a transmission pathway the intervention is thought to block (waterborne transmission). These findings certainly merit future research, but we recommend caution in over-interpreting the result by itself because it was the only measure of health improvement among many measured in this study.

The majority of intervention studies in the water, sanitation, and hygiene sector have used caregiver reported diarrhea as their primary outcome [41], which theoretically could be subject to differential, biased reporting in unblinded trials [27,28]. We included numerous objective child

health outcomes in this study (parasite infection, anemia, anthropometry) to complement caregiver-reported diarrhea. However, we did not include objective measures of sanitation behavior (disposal of child feces, toilet use and open defecation), which relied on reports from study participants. To the extent that our measurements of reported outcomes were subject to courtesy bias, we may have over-estimated toilet use and under-estimated open defecation prevalence in the study population. Furthermore, if the bias was differential by treatment group, then we would expect the study to have over-estimated the improvements due to intervention because we would expect the intervention households to be more sensitized to the stigma of open defecation. Measures of toilet use could be improved in future sanitation studies through the use of passive sensors mounted in the latrine [51].

Conclusions

Despite encouraging increases in toilet construction and reductions in open defecation, we found no consistent evidence for improvements in multiple health outcomes among children < 24 months at enrollment. The lack of impact on downstream measures such as anemia and height-for-age would be expected given the delay in program implementation and relatively short exposure period by the follow-up survey. Intervention impacts on more proximate infectious outcomes, including diarrhea or intestinal parasite infections, were plausible under the timeline of the current study, but were not observed. The present study cannot rule out multiple competing hypotheses for lack of impact on infectious outcomes, which include: inadequate exposure time to the intervention, insufficient reductions in open defecation, and other dominant transmission pathways (e.g., person-to-person).

However, the present study documents that India's TSC was effective at convincing rural Indian households to build improved toilets but the corresponding reduction in open defecation has been less. Even among intervention households with a JMP improved toilet, 41% report that adults still practice daily open defecation. Toilet use has clearly lagged behind toilet construction, and even following intervention there remains room for large improvements in both toilet construction and sanitation related behavior change. The majority of adults (74%) in intervention villages report that they still practice daily open defecation, and open defecation among children < 5 remains even higher (84%).

The study also found that subsidies provide a strong incentive for rural Indian households to build toilets and reduce open defecation, particularly among poor households who received the largest subsidy. Households below the poverty line (BPL) were far more likely to build toilets (+31%) than non BPL households (+15%). Nevertheless, the use of constructed toilets appears to lag behind their construction: although BPL households were less likely to report daily adult open defecation (-19%) compared to non BPL households (-6%), these reductions were not commensurate with the increase in toilet construction. These results suggest that subsidies likely accelerate toilet construction, but are insufficient to guarantee use. An assessment of 56 districts across India by WSP identified processes related to improved performance under TSC [52].

WSP assessment identified that in high performing districts (>90% toilet use in a representative survey of GPs that won NGP award) the subsidy for toilet construction was given as an incentive whereas in low performing districts (<35% toilet use) subsidy was used to push toilet construction without commensurate efforts at demand creation. This impact evaluation is not designed to answer how the subsidy affects sustainability of the use of toilets or to study different subsidy mechanisms. However, this study provides a basis for future research to answer these questions.

Taken together, the study suggests that the TSC program shows promise for the successful expansion of access to improved sanitation in rural India. However, the challenge faced by rural India is increasing the use of newly constructed toilets to achieve commensurate reductions in open defecation. Additional measures of toilet construction, use, and maintenance over longer time periods in this cohort would provide additional evidence to support or refute whether the improvements observed in the present study are sustained (or even expanded) over a longer period. To the extent that such improvements reduce pathogen transmission, we would expect larger health improvements than those observed in the present study.

References

1. Mara D, Lane J, Scott B, Trouba D (2010) Sanitation and health. *PLoS Med* 7: e1000363. doi:10.1371/journal.pmed.1000363.
2. UNICEF, WHO (2012) World Health Organization and United Nations Children's Fund Joint Monitoring Programme for Water Supply and Sanitation (JMP). Progress on Drinking Water and Sanitation: 2012 Update. New York and Geneva: UNICEF and WHO.
3. Unicef, WHO (2009) Diarrhoea: Why children are still dying and what can be done. Unicef / WHO.
4. Clasen TF, Bostoen K, Schmidt W-P, Boisson S, Fung IC-H, et al. (2010) Interventions to improve disposal of human excreta for preventing diarrhoea. *Cochrane Database Syst Rev* 6. doi:http://dx.doi.org/10.1002/14651858.CD007180.pub2.
5. Norman G, Pedley S, Takkouche B (2010) Effects of sewerage on diarrhoea and enteric infections: a systematic review and meta-analysis. *Lancet Infect Dis* 10: 536–544. doi:10.1016/S1473-3099(10)70123-7.
6. Barreto ML, Genser B, Strina A, Teixeira MG, Assis AMO, et al. (2010) Impact of a City-Wide Sanitation Programme in Northeast Brazil on Intestinal Parasites Infection in Young Children. *Environ Health Perspect*. Available: <http://www.ncbi.nlm.nih.gov/pubmed/20705544>. Accessed 20 November 2010.
7. Mascarini-Serra LM, Telles CA, Prado MS, Mattos SA, Strina A, et al. (2010) Reductions in the prevalence and incidence of geohelminth infections following a city-wide sanitation program in a Brazilian Urban Centre. *PLoS Negl Trop Dis* 4: e588. doi:10.1371/journal.pntd.0000588.
8. Ziegelbauer K, Speich B, Mäusezahl D, Bos R, Keiser J, et al. (2012) Effect of sanitation on soil-transmitted helminth infection: systematic review and meta-analysis. *PLoS Med* 9: e1001162. doi:10.1371/journal.pmed.1001162.
9. Kar K, Chambers R (2008) Handbook on Community-Led Total Sanitation. Plan International (UK). Available: <http://www.communityledtotalsanitation.org/resource/handbook-community-led-total-sanitation>. Accessed 12 February 2013.
10. Chavasse DC, Shier RP, Murphy OA, Huttly SR, Cousens SN, et al. (1999) Impact of fly control on childhood diarrhoea in Pakistan: community-randomised trial. *Lancet* 353: 22–25.
11. Emerson PM, Lindsay SW, Alexander N, Bah M, Dibba S-M, et al. (2004) Role of flies and provision of latrines in trachoma control: cluster-randomised controlled trial. *Lancet* 363: 1093–1098. doi:10.1016/S0140-6736(04)15891-1.
12. Emerson PM, Simms VM, Makalo P, Bailey RL (2005) Household pit latrines as a potential source of the fly *Musca sorbens*—a one year longitudinal study from The Gambia. *Trop Med Int Health* 10: 706–709. doi:10.1111/j.1365-3156.2005.01432.x.
13. Checkley W, Buckley G, Gilman RH, Assis AM, Guerrant RL, et al. (2008) Multi-country analysis of the effects of diarrhoea on childhood stunting. *Int J Epidemiol* 37: 816–830. doi:10.1093/ije/dyn099.

14. Schmidt W-P, Boisson S, Genser B, Barreto ML, Baisley K, et al. (2010) Weight-for-age z-score as a proxy marker for diarrhoea in epidemiological studies. *J Epidemiol Community Health* 64: 1074–1079. doi:10.1136/jech.2009.099721.
15. Humphrey JH (2009) Child undernutrition, tropical enteropathy, toilets, and handwashing. *Lancet* 374: 1032–1035.
16. Prendergast A, Kelly P (2012) Enteropathies in the developing world: neglected effects on global health. *Am J Trop Med Hyg* 86: 756–763. doi:10.4269/ajtmh.2012.11-0743.
17. Checkley W, Gilman RH, Black RE, Epstein LD, Cabrera L, et al. (2004) Effect of water and sanitation on childhood health in a poor Peruvian peri-urban community. *Lancet* 363: 112–118.
18. Pattanayak SK, Yang JC, Dickinson KL, Poulos C, Patil SR, et al. (2009) Shame or subsidy revisited: social mobilization for sanitation in Orissa, India. *Bull World Health Organ* 8: 580–587.
19. Waterkeyn J, Cairncross S (2005) Creating demand for sanitation and hygiene through Community Health Clubs: a cost-effective intervention in two districts in Zimbabwe. *Soc Sci Med* 61: 1958–1970.
20. O’Loughlin R, Fentie G, Flannery B, Emerson PM (2006) Follow-up of a low cost latrine promotion programme in one district of Amhara, Ethiopia: characteristics of early adopters and non-adopters. *Trop Med Int Health* 11: 1406–1415.
21. Cameron L, Shah M, Olivia S (2013) Impact Evaluation of a Rural Sanitation Behavior Change Project in Indonesia. World Bank.
22. Kar K (2003) Subsidy or self-respect? Participatory total community sanitation in Bangladesh.
23. Goldman N, Vaughan B, Pebley AR (1998) The use of calendars to measure child illness in health interview surveys. *Int J Epidemiol* 27: 505–512.
24. Arnold BF, Galiani S, Ram PK, Hubbard AE, Briceño B, et al. (2013) Optimal Recall Period for Caregiver-reported Illness in Risk Factor and Intervention Studies: A Multicountry Study. *Am J Epidemiol* 177: 361–370. doi:10.1093/aje/kws281.
25. Baqui AH, Black RE, Yunus M, Hoque AR, Chowdhury HR, et al. (1991) Methodological issues in diarrhoeal diseases epidemiology: definition of diarrhoeal episodes. *Int J Epidemiol* 20: 1057–1063.
26. Lipsitch M, Tchetgen ET, Cohen T (2010) Negative controls: a tool for detecting confounding and bias in observational studies. *Epidemiology* 21: 383–388. doi:10.1097/EDE.0b013e3181d61eeb.
27. Wood L, Egger M, Gluud LL, Schulz KF, Vandenbroucke JP, et al. (2008) Empirical evidence of bias in treatment effect estimates in controlled trials with different interventions and outcomes: meta-epidemiological study. *BMJ* 336: 601–605. doi:http://dx.doi.org/10.1136/bmj.39465.451748.AD.
28. Schmidt W-P, Cairncross S (2009) Household Water Treatment in Poor Populations: Is There Enough Evidence for Scaling up Now? *Environ Sci Technol* 43: 986–992.

29. Cogill B (2003) Anthropometric indicators measurement guide. Washington, D.C.: Food and Nutrition Technical Assistance Project, Academy for Educational Development.
30. de Onis M, Onyango AW, Broeck JV den, Chumlea WC, Martorell R (2004) Measurement and standardization protocols for anthropometry used in the construction of a new international growth reference. *Food Nutr Bull* 25: S27–S36.
31. WHO (2006) WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and developments.
32. WHO (2011) Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Vitamin and Mineral Nutrition Information System. Geneva, World Health Organization.
33. Helsel DR (1990) Less Than Obvious - Statistical Treatment of Data Below the Detection Limit. *Environ Sci & Technol* 24: 1766–1774.
34. Katz N, Chaves A, Pellegrino J (1972) A simple device for quantitative stool thick-smear technique in Schistosomiasis mansoni. *Rev Inst Med Trop Sao Paulo* 14: 397–400.
35. Garcia LS, Shimizu RY (1997) Evaluation of nine immunoassay kits (enzyme immunoassay and direct fluorescence) for detection of *Giardia lamblia* and *Cryptosporidium parvum* in human fecal specimens. *J Clin Microbiol* 35: 1526–1529.
36. den Hartog J, Rosenbaum L, Wood Z, Burt D, Petri, Jr WA (2013) Diagnosis of multiple enteric protozoan infections by enzyme-linked immunosorbent assay in the guatemalan highlands. *Am J Trop Med Hyg* 88: 167–171. doi:10.4269/ajtmh.2012.12-0142.
37. Cacciò SM, De Giacomo M, Pozio E (2002) Sequence analysis of the beta-giardin gene and development of a polymerase chain reaction-restriction fragment length polymorphism assay to genotype *Giardia duodenalis* cysts from human faecal samples. *Int J Parasitol* 32: 1023–1030.
38. Xiao L, Escalante L, Yang C, Sulaiman I, Escalante AA, et al. (1999) Phylogenetic analysis of *Cryptosporidium* parasites based on the small-subunit rRNA gene locus. *Appl Environ Microbiol* 65: 1578–1583.
39. Gonin P, Trudel L (2003) Detection and differentiation of *Entamoeba histolytica* and *Entamoeba dispar* isolates in clinical samples by PCR and enzyme-linked immunosorbent assay. *J Clin Microbiol* 41: 237–241.
40. Freedman DA (2006) On the so-called “Huber sandwich estimator” and “robust standard errors.” *Am Stat* 60: 299–302.
41. Waddington H, Snilstveit B (2009) Effectiveness and sustainability of water, sanitation, and hygiene interventions in combating diarrhoea. *J Dev Eff* 1: 295–335.
42. Roberts LS, Janovy J (2009) *Foundations of Parasitology*. 8th ed. United States: McGraw-Hill.
43. Petri WA, Guerrant RL, Miller M, Binder HJ, Levine MM, et al. (2008) Enteric infections, diarrhea, and their impact on function and development. *J Clin Invest* 118: 1277–1290.

44. Spears D (2012) Effects of Rural Sanitation on Infant Mortality and Human Capital: Evidence from India's Total Sanitation Campaign (July 3, 2012 draft). Princeton University.
45. Hammer J, Spears D (2013) Village sanitation externalities and children's human capital: Evidence from a randomized experiment by the Maharashtra government (Feb 3, 2013 draft). Princeton University.
46. Dewey KG, Adu-Afarwuah S (2008) Systematic review of the efficacy and effectiveness of complementary feeding interventions in developing countries. *Matern Child Nutr* 4 Suppl 1: 24–85. doi:<http://dx.doi.org/10.1111/j.1740-8709.2007.00124.x>.
47. Bhutta ZA, Ahmed T, Black RE, Cousens S, Dewey K, et al. (2008) What works? Interventions for maternal and child undernutrition and survival. *Lancet* 371: 417–440.
48. Victora CG, de Onis M, Hallal PC, Blossner M, Shrimpton R (2010) Worldwide timing of growth faltering: revisiting implications for interventions. *Pediatrics* 125: e473–e480. doi:<http://dx.doi.org/10.1542/peds.2009-1519>.
49. Huda TMN, Unicomb L, Johnston RB, Halder AK, Sharker MAY, et al. (2012) Interim evaluation of a large scale sanitation, hygiene and water improvement programme on childhood diarrhea and respiratory disease in rural Bangladesh. *Soc Sci Med* 75: 604–611. doi:10.1016/j.socscimed.2011.10.042.
50. Arnold BF, Khush RS, Ramaswamy P, London AG, Rajkumar P, et al. (2010) Causal inference methods to study nonrandomized, preexisting development interventions. *Proc Natl Acad Sci U S A* 107: 22605 – 22610. doi:10.1073/pnas.1008944107.
51. Clasen T, Fabini D, Boisson S, Taneja J, Song J, et al. (2012) Making sanitation count: Developing and testing a device for assessing latrine use in low-income settings. *Environ Sci Technol*. Available: <http://dx.doi.org/10.1021/es2036702>.
52. Water and Sanitation Program (WSP) (2010). Linking Service Delivery Processes and Outcomes in Rural Sanitation: Findings from 56 Districts in India. Global Scaling Up Sanitation Project Report.

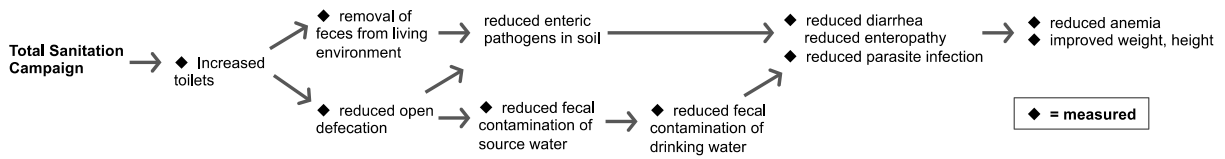


Figure 1. Hypothesized causal mechanisms for intervention impact, and measurements in the evaluation.

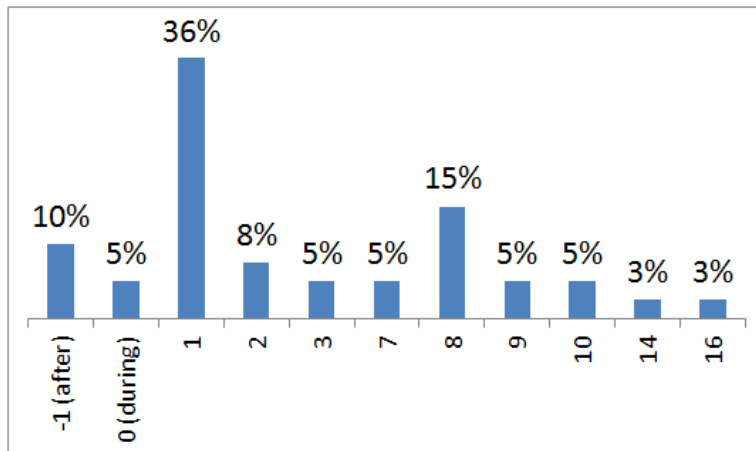


Figure 1. Timing of latest Community-Led Total Sanitation triggering in intervention villages relative to follow-up survey according to Block TSC Coordinators

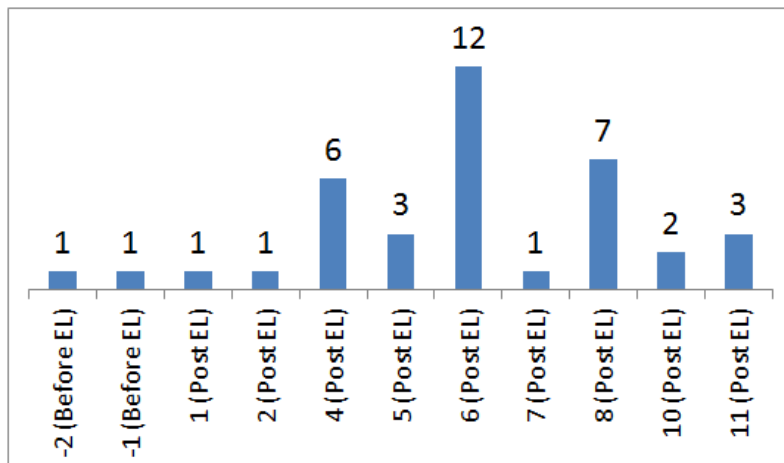


Figure 2. Expected time for the village to become ODF relative to follow-up survey based on the opinion of Block TSC Coordinators

Table 1. Number of Household Questionnaires Completed in Baseline and Follow-up Surveys and Attrition of Samples

Region	Follow-up			Baseline			Intact Panel			Attrition [Number (%)]		
	Treat	Control	Total	Treat	Control	Total	Treat	Control	Total	Treat	Control	Total
DHAR	762	756	1,518	487	482	969	404	394	798	83 (17%)	88 (18%)	171 (18%)
Bagh	77	71	148	40	49	89	35	24	59	5 (13%)	25 (51%)	30 (34%)
Dahi	38	38	76	26	25	51	25	23	48	1 (4%)	2 (8%)	3 (6%)
Dhar	78	76	154	50	50	100	40	41	81	10 (20%)	9 (18%)	19 (19%)
Gandhwani	73	77	150	50	50	100	39	45	84	11 (22%)	5 (10%)	16 (16%)
Kukshi	38	38	76	25	25	50	17	24	41	8 (32%)	1 (4%)	9 (18%)
Manawar	78	77	155	49	49	98	43	45	88	6 (12%)	4 (8%)	10 (10%)
Nalchha	76	76	152	49	47	96	35	33	68	14 (29%)	14 (30%)	28 (29%)
Nisarpur	76	76	152	49	38	87	38	26	64	11 (22%)	12 (32%)	23 (26%)
Sardarpur	114	113	227	75	74	149	64	67	131	11 (15%)	7 (9%)	18 (12%)
Tirla	38	38	76	24	25	49	21	22	43	3 (13%)	3 (12%)	6 (12%)
Umarban	76	76	152	50	50	100	47	44	91	3 (6%)	6 (12%)	9 (9%)
KHARGONE	763	758	1,521	489	496	985	418	439	857	71 (15%)	57 (11%)	128 (13%)
Barwah	152	151	303	99	97	196	82	88	170	17 (17%)	9 (9%)	26 (13%)
Bhagvanpura	76	76	152	50	50	100	38	45	83	12 (24%)	5 (10%)	17 (17%)
Bhikangaon	77	76	153	49	49	98	40	39	79	9 (18%)	10 (20%)	19 (19%)
Gogawan	77	76	153	49	50	99	41	44	85	8 (16%)	6 (12%)	14 (14%)
Kasrawad	114	114	228	70	75	145	65	69	134	5 (7%)	6 (8%)	11 (8%)
Khargone	76	75	151	48	50	98	44	44	88	4 (8%)	6 (12%)	10 (10%)
Maheshwar	114	114	228	74	75	149	65	67	132	9 (12%)	8 (11%)	17 (11%)
Ziranya	77	76	153	50	50	100	43	43	86	7 (14%)	7 (14%)	14 (14%)
TOTAL	1,525	1,514	3,039	976	978	1,954	822	833	1,655	154 (16%)	145 (15%)	299 (15%)

Table 2. Test for Baseline Balance in Covariates after randomization.

	Intervention (I)		Control (C)		I - C	
	N	Mean	N	Mean	Mean	SE
Household Characteristics						
Number of members in a Household	976	6.95	978	6.82	0.13	0.14
U5 Children Age in months	1683	21.89	1707	22.12	-0.23	0.45
Age of HH Head	976	45.34	978	43.18	2.16	1.12*
Whether HH Head went to school	954	0.50	952	0.53	-0.03	0.05
SCST HHs	935	0.70	905	0.71	-0.02	0.05
Household construction type	976	0.57	978	0.60	-0.03	0.05
Monthly HH income (module 3 & 4)	976	11293	978	11022	271	1072
PC based wealth index	962	-0.14	964	-0.15	0.01	0.24
WASH Behaviors						
JMP defined improved water source	976	0.89	978	0.80	0.10	0.05**
Self-reported drinking water treatment	976	0.68	978	0.66	0.02	0.04
Food is completely covered	968	0.64	969	0.60	0.04	0.04
Soap & water present, HW place used post defecation	969	0.44	972	0.54	-0.10	.06^
PCG of u5 child reports HW w/ soap after fecal contact in last 24 Hrs	978	0.62	985	0.64	-0.02	0.04
Child Nutrition						
Child ever breastfed ^{&}	1026	0.99	1037	0.99	0.00	0.01
Child Still breastfeeding ^{&}	1013	0.91	1021	0.90	0.02	0.01
Iron pills, syrup given [#]	1019	0.07	1033	0.06	0.01	0.02
Drugs for intestinal worms given past 6 [#]	1025	0.19	1033	0.16	0.03	0.02
Did receive VitA dose last 6 months [#]	1013	0.30	1029	0.32	-0.01	0.03
Program Outputs/Outcomes						
JMP Improved Sanitation	975	0.14	978	0.12	0.01	0.03
JMP correct child feces disposal	976	0.16	978	0.13	0.03	0.03

	Intervention (I)		Control (C)		I - C	
	N	Mean	N	Mean	Mean	SE
Garbage obs. in kitchen or house	974	0.39	972	0.43	-0.04	0.03
Feces are not observed in living area around HH	973	0.41	976	0.38	0.03	0.05
Health Status						
Diarrhea 7-day prevalence [#]	1683	0.13	1707	0.12	0.01	0.02
Diarrhea 14-day prevalence [#]	1683	0.15	1707	0.15	0.01	0.02
ALRI 7-day prevalence [#]	1683	0.11	1707	0.10	0.01	0.03
ALRI 14-day prevalence [#]	1683	0.13	1707	0.11	0.02	0.03
Child weight (to 0.1 kg) [#]	957	7.04	943	6.99	0.05	0.09
Child height (to 0.1 cm) [#]	932	69.43	933	68.11	1.33	0.65**
Child arm circ. (to 0.1 cm [#])	921	13.01	895	12.99	0.02	0.13
Weight-for-age z-score [#]	957	-2.20	943	-2.18	-0.02	0.09
Length/height-for-age z-score [#]	932	-1.38	933	-1.81	0.42	0.22*
Arm Circ-for-age z-score [#]	921	-1.31	895	-1.33	0.02	0.12
Weight-for-height z-score [#]	895	-1.68	879	-1.43	-0.25	0.16
Anemic: Hb < 110 g/l [#]	293	0.88	329	0.93	-0.05	0.02*
Water Microbiology						
Log ₁₀ <i>E. coli</i> in household drinking water (CFU/100 ml)	172	2.01	174	2.06	-0.05	0.09
Houshold drinking water is contaminated with <i>E. coli</i>	172	0.96	174	0.98	-0.02	0.02

& For children less than 24 months of age

For children less than 60 months of age

z-test is used for the group mean by clustering standard error at GP level. The significance is noted as:

- ^ Statistically significant at □ = 0.15
- * Statistically significant at □ = 0.1
- ** Statistically significant at □ = 0.05
- *** Statistically significant at □ = 0.01

Table 3. Analysis of Attrition in the baseline panel

Indicators	Attrition/Lost Households						Intact Households					
	T		C		T-C		T		C		T-C	
	N	Mean	N	Mean	Mean	SE	N	Mean	N	Mean	Mean	SE
Household Characteristics												
Number of members in a Household	154	6.45	145	6.68	-0.23	0.31	822	7.04	833	6.84	0.20	0.15
U5 Children Age in months	263	22.26	247	22.05	0.20	1.24	1420	21.82	1460	22.13	-0.31	0.48
Age of HH Head	154	41.26	145	42.74	-1.48	2.18	822	46.1	833	43.26	2.84	1.19**
Whether HH Head went to school	150	0.39	143	0.38	0.01	0.08	804	0.52	809	0.55	-0.03	0.05
SCST HHs	150	0.85	130	0.77	0.08	0.07	785	0.67	775	0.7	-0.04	0.06
Household construction type	154	0.48	145	0.6	-0.12	0.07	822	0.59	833	0.61	-0.02	0.05
monthly HH income (module 3 & 4)	154	4601	145	5790	-1189	1364	822	12547	833	11933	614	1140
PC based wealth index	151	-0.93	142	-0.29	-0.64	0.36*	811	0.01	822	-0.13	0.14	0.25
WaSH Behaviors												
JMP defined improved water source	154	0.86	145	0.86	0.00	0.05	822	0.9	833	0.79	0.11	0.05**
Self-reported drinking water treatment	154	0.6	145	0.64	-0.04	0.06	822	0.7	833	0.67	0.03	0.04
Food is completely covered	154	0.56	145	0.51	0.05	0.06	814	0.66	824	0.62	0.04	0.04
Soap & water present, HW place used post	153	0.33	144	0.4	-0.07	0.07	816	0.47	828	0.57	-0.10	0.06
PCG of u5 child reports HW w/ soap after fecal contact in last 24 Hrs	151	0.56	145	0.59	-0.04	0.06	827	0.63	840	0.65	-0.02	0.04
Child Nutrition												
Child ever breastfed ^{&}	160	0.97	153	0.99	-0.02	0.02	866	0.99	884	0.98	0.01	0.01*
Child Still breastfeeding ^{&}	153	0.92	152	0.87	0.05	0.04	860	0.91	869	0.9	0.01	0.01
Iron pills, syrup given [#]	158	0.09	153	0.07	0.02	0.03	861	0.07	880	0.06	0.01	0.02
Drugs for intestinal worms given past 6 [#]	160	0.18	153	0.16	0.02	0.05	865	0.19	880	0.16	0.03	0.02
Did receive VitA dose last 6 months [#]	156	0.26	152	0.33	-0.07	0.05	857	0.31	877	0.31	0.00	0.03
Program Outputs/Outcomes												
JMP Improved Sanitation	154	0.05	145	0.08	-0.03	0.05	821	0.15	833	0.13	0.02	0.04

JMP correct child feces disposal	154	0.1	145	0.12	-0.02	0.04	822	0.17	833	0.14	0.03	0.03
Garbage obs. in kitchen or house	154	0.45	145	0.42	0.03	0.06	820	0.38	827	0.43	-0.05	0.03
Feces are not observed in living area around HH	152	0.41	144	0.34	0.07	0.06	821	0.41	832	0.39	0.02	0.05
Health Status												
Diarrhea 7-day prevalence [#]	263	0.13	247	0.13	0.00	0.04	1420	0.13	1460	0.12	0.01	0.02
Diarrhea 14-day prevalence [#]	263	0.14	247	0.15	-0.01	0.04	1420	0.16	1460	0.15	0.01	0.02
ALRI 7-day prevalence [#]	263	0.14	247	0.11	0.02	0.05	1420	0.11	1460	0.1	0.01	0.03
ALRI 14-day prevalence [#]	263	0.15	247	0.12	0.03	0.05	1420	0.13	1460	0.11	0.01	0.03
Child weight (to 0.1 kg) [#]	141	6.86	131	6.89	-0.03	0.21	816	7.07	812	7.01	0.07	0.09
Child height (to 0.1 cm) [#]	141	69.3	126	68.3	1.02	1.23	791	69.46	807	68.08	1.38	0.65**
Child arm circ. (to 0.1 cm [#])	139	12.8	122	12.9	-0.10	0.26	782	13.05	773	13.00	0.05	0.13
Weight-for-age z-score [#]	141	-2.41	131	-2.14	-0.27	0.16*	816	-2.16	812	-2.186	0.03	0.09
Length/height-for-age z-score [#]	141	-1.41	126	-1.54	0.13	0.34	791	-1.38	807	-1.85	0.47	0.22**
Arm Circ-for-age z-score [#]	139	-1.52	122	-1.37	-0.15	0.23	782	-1.27	773	-1.32	0.05	0.12
Weight-for-height z-score [#]	135	-1.85	118	-1.57	-0.28	0.24	760	-1.65	761	-1.41	-0.24	0.16
Anemic: Hb < 110 g/l [#]	43	0.88	36	0.94	-0.06	0.08	250	0.88	293	0.92	-0.04	0.02*
Water Microbiology												
Log ₁₀ <i>E. coli</i> in household drinking water (CFU/100 ml)	24	2.08	22	1.99	0.10	0.20	148	2	152	2.07	-0.07	0.09
Household drinking water is contaminated with <i>E. coli</i>	24	0.96	22	0.95	0.00	0.06	148	0.96	152	0.98	-0.02	0.02

& For children less than 24 months of age

For children less than 60 months of age

z-test is used for the group mean by clustering standard error at GP level. The significance is noted as:

* $P < 0.1$ ** $P < 0.05$ *** $P < 0.01$

Table 4. Program Implementation as per Block Coordinator Interview and Records for Intervention Villages (*Gram Panchayats*; GPs)

Block	No of GPs	Timing of latest TSC related activities wrt EL (Feb 2011)			No of trt GPs where CLTS triggering is done	No of Months latest triggering done before EL			No of GPs where Post triggering Follow up activities are done	Total No of HH in GPs	% of HHs with IHL	% of HHs with U/C toilets	% of IHL in use – opinion of BC
		After	1-3 mths before	4-6 mths before		Mean	Min	Max					
Dhar District	Bagh	2	0	0	2	1	1	1	0	732	64%	35%	50%
	Dahi	1	0	1	0	8	8	8	0	339	89%	11%	10%
	Dhar	2	0	2	0	1	1	1	2	966	61%	39%	10%
	Gandhwani	2	0	0	2	1	1	1	0	1071	49%	51%	10%
	Kukshi	1	0	1	0	-1	-1	-1	1	568	91%	10%	50%
	Manawar	2	0	2	0	2	2	2	0	770	90%	10%	75%
	Nalchha	1	0	1	0	0	0	0	1	333	83%	0%	10%
	Nisarpur	2	0	0	2	8	8	8	0	953	88%	1%	10%
	Sardarpur	3	1	0	0	-1	-1	-1	0	1415	95%	5%	63%
	Tirla	1	1	0	0	16	16	16	1	243	51%	16%	10%
Khargone District	Umarban	2	0	2	0	7	0	14	1	851	97%	3%	85%
	Barwah	4	0	4	0	1	1	1	0	1964	62%	20%	70%
	Bhagvanpura	2	0	0	2	8	8	8	2	853	91%	6%	60%
	Bhikangaon	2	0	0	2	10	10	10	0	824	80%	25%	18%
	Gogawan	2	0	0	2	1	1	1	0	979	47%	53%	50%
	Kasrawad	3	0	3	0	1.33	1	2	0	2060	66%	68%	68%
	Khargone	2	0	2	0	3	3	3	0	735	67%	33%	70%
	Maheshwar	3	3	0	0	8.67	8	9	3	2382	59%	9%	58%
	Ziranya	2	0	0	2	7	7	7	0	1267	82%	17%	90%

Table 5. Implementation of TSC program at GP level and program exposure of the households

Variable Description	DHAR						KHARGONE						COMBINED					
	T		C		T-C		T		C		T-C		T		C		T-C	
	N	Mean	N	Mean	Mean	SE	N	Mean	N	Mean	Mean	SE	N	Mean	N	Mean	Mean	SE
Implementation of and Exposure to Program in GP as per GP Secretary Interview																		
Implemented TSC activities or received TSC funds	20	0.60	20	0.45	0.15	0.16	18	0.83	20	0.30	0.53	0.14***	38	0.71	40	0.38	0.34	0.11***
Implemented TSC activities or received TSC funds or Nirmal Vatika funds	20	0.50	20	0.20	0.30	0.15**	18	0.83	20	0.25	0.58	0.13***	38	0.66	40	0.23	0.43	0.1**
Report some CLTS triggering activity in GP	20	0.95	20	0.50	0.45	0.12***	18	0.89	20	0.65	0.24	0.13*	38	0.92	40	0.58	0.35	0.09***
% of GP secys personally exposed to any CLTS tool	18	1.00	18	0.89	0.11	0.07	16	0.94	19	0.95	-0.01	0.08	34	0.97	37	0.92	0.05	0.05
Avg No of CLTS tools GP secy exposed to	18	6.50	18	4.22	2.28	0.81***	16	6.63	19	5.16	1.47	1.01	34	6.56	37	4.70	1.86	0.65***
Implementation of and Exposure to Program as per School teachers interview																		
Avg No of schools in GP	19	4.68	20	3.85	0.83	0.59	20	4.05	18	3.33	0.72	0.51	39	4.36	38	3.61	0.75	0.4*
% of schools in GP exposed to any CLTS	19	0.87	20	0.81	0.06	0.10	20	0.96	18	0.89	0.07	0.07	39	0.92	38	0.85	0.07	0.06
Avg No of CLTS tools school were exposed	19	5.45	20	4.52	0.93	0.85	20	5.57	18	3.15	2.42	0.61***	39	5.51	38	3.87	1.64	0.53***
% of Schools in GP with toilets	19	0.71	20	0.45	0.26	0.11**	20	0.62	18	0.49	0.14	0.13	39	0.67	38	0.47	0.20	0.08**
% of schools reporting toilet construction post baseline	19	0.13	20	0.08	0.05	0.06	20	0.31	18	0.18	0.14	0.14	39	0.22	38	0.13	0.10	0.08
Implementation of and Exposure to Program as per Anganwadi workers Interview																		
Avg No of Anganwadis in GP	20	3.30	20	3.05	0.25	0.29	20	3.05	20	2.90	0.15	0.47	40	3.18	40	2.98	0.20	0.27
% of AW in GP exposed to any CLTS tool	20	0.94	20	0.74	0.20	0.09**	20	0.98	20	0.91	0.06	0.04	40	0.96	40	0.83	0.13	0.05**
Avg No of CLTS tools AWs were exposed to	20	5.61	20	4.08	1.52	0.87*	20	6.22	20	4.43	1.79	0.65***	40	5.91	40	4.26	1.66	0.54***
% of AW observed to have toilet	20	0.26	20	0.18	0.08	0.09	20	0.21	20	0.19	0.02	0.11	40	0.24	40	0.18	0.05	0.07
% of AW reporting toilet construction post baseline	20	0.65	20	0.78	-0.14	0.10	20	0.67	20	0.71	-0.04	0.11	40	0.66	40	0.75	-0.09	0.07
Implementation of and Exposure to Program as per Transect Walk (rapid HH survey)																		
% of HHs aware about TSC	1000	0.37	920	0.43	-0.06	0.11	980	0.32	980	0.33	0.00	0.11	1980	0.35	1900	0.38	-0.03	0.08

Variable Description	DHAR						KHARGONE						COMBINED					
	T		C		T-C		T		C		T-C		T		C		T-C	
	N	Mean	N	Mean	Mean	SE	N	Mean	N	Mean	Mean	SE	N	Mean	N	Mean	Mean	SE
% of HH with usable toilets (Observed)	1000	0.40	920	0.22	0.18	0.1*	980	0.32	980	0.17	0.15	0.09*	1980	0.36	1900	0.19	0.17	0.07**
% of HH with under construction IHL (observed)	1000	0.14	920	0.06	0.07	0.04*	980	0.24	980	0.08	0.16	0.13	1980	0.19	1900	0.07	0.11	0.07*
% of HH with toilet superstructure (door, roof, walls - observed)	1000	0.13	920	0.13	0.01	0.05	980	0.14	980	0.15	-0.02	0.06	1980	0.14	1900	0.14	-0.01	0.04
% of HH with water near IHL	1000	0.17	920	0.16	0.00	0.07	980	0.15	980	0.12	0.03	0.04	1980	0.16	1900	0.14	0.02	0.04
% of HH where possibility of use is confirmed by enumerators	1000	0.33	920	0.20	0.12	0.09	980	0.23	980	0.17	0.06	0.09	1980	0.28	1900	0.19	0.10	0.06
<i>Exposure of Individual households to program related activities (main HH survey)</i>																		
Did HH receive WaSH msg from mass media	765	0.27	759	0.26	0.01	0.05	763	0.32	757	0.29	0.03	0.05	1528	0.30	1516	0.27	0.02	0.04
Did HH change Wash behavior due to mass media	765	0.19	759	0.16	0.03	0.05	763	0.23	757	0.20	0.03	0.05	1528	0.21	1516	0.18	0.03	0.03
Did HH receive WaSH msg from personal Visits	744	0.21	733	0.13	0.09	0.04**	740	0.26	744	0.07	0.19	0.04***	1484	0.24	1477	0.10	0.14	0.03***
Did HH change Wash behavior due to Personal visits	744	0.13	733	0.06	0.07	0.03***	740	0.17	744	0.05	0.12	0.03***	1484	0.15	1477	0.05	0.09	0.02***
Did HH participate or is aware of any of CLTS triggering activities	766	0.26	760	0.18	0.08	0.05*	764	0.32	759	0.14	0.18	0.04***	1530	0.29	1519	0.16	0.13	0.03***
Does HH know of masons to build toilets	766	0.65	760	0.64	0.01	0.05	764	0.79	758	0.77	0.02	0.04	1530	0.72	1518	0.70	0.01	0.04
Does HH know of shop to buy toilet mater	766	0.74	760	0.81	-0.07	0.05	764	0.87	759	0.88	-0.01	0.04	1530	0.80	1519	0.85	-0.04	0.03
Does HH know of about TSC/NGP program	766	0.25	760	0.22	0.03	0.05	764	0.30	759	0.21	0.09	0.05**	1530	0.27	1519	0.21	0.06	0.04*

z-test is used for the group mean by clustering standard error at GP level. The significance is noted as:

* $P < 0.1$ ** $P < 0.05$ *** $P < 0.01$

Table 6. Trend between baseline and follow-up surveys in the intervention and control groups.

Description	CONTROL						INTERVENTION					
	Follow-up (F)		Baseline (B)		F-B		Follow-up (F)		Baseline (B)		F-B	
	N	Mean	N	N	Mean	N	N	Mean	N	Mean	Mean	SE
Household Characteristics												
Number of members in a Household	1514	7.04	996	6.80	0.24	0.13*	1525	7.11	996	6.96	0.16	0.13
U5 Children Age in months	2609	29.40	1737	22.13	7.27	0.45***	2600	28.79	1719	21.93	6.86	0.42***
Age of HH Head	1514	43.17	996	43.15	0.02	1.01	1525	43.42	996	45.42	-2.00	1.01**
Whether HH Head went to school	1506	0.52	969	0.53	-0.01	0.04	1513	0.57	972	0.49	0.07	0.04*
SCST HHs	1489	0.71	922	0.71	0.00	0.05	1508	0.65	951	0.70	-0.05	0.06
Household construction type	1514	0.61	996	0.61	0.00	0.05	1525	0.64	996	0.57	0.06	0.05
monthly HH income (module 3 & 4)	1514	9172	996	11024	-1853	906**	1525	10780	996	11241	-461	1411
PC based wealth index	1509	0.02	982	-0.14	0.16	0.26	1523	0.16	982	-0.14	0.30	0.24
WaSH Behaviors												
JMP defined improved water source	1514	0.95	996	0.80	0.15	0.04***	1525	0.97	996	0.89	0.08	0.03***
Self-reported drinking water treatment	1514	0.68	996	0.67	0.01	0.04	1525	0.67	996	0.69	-0.02	0.04
Food is completely covered	1156	0.78	987	0.60	0.18	0.03***	1190	0.77	988	0.64	0.13	0.03***
Soap & water present, HW place used post	1269	0.44	990	0.54	-0.11	0.05**	1334	0.49	989	0.44	0.05	0.05
HW w/ soap after fecal contact in last 24 Hrs	1498	0.59	1003	0.64	-0.05	0.04	1512	0.61	998	0.61	0.00	0.04
Child Nutrition												
Child ever breastfed	771	0.98	1055	0.99	-0.01	0.01	812	0.98	1046	0.99	-0.01	0.01
Child Still breastfeeding	753	0.90	1039	0.90	0.01	0.01	795	0.88	1033	0.91	-0.03	0.02**
Iron pills, syrup given	2341	0.01	1051	0.06	-0.05	0.01***	2296	0.02	1039	0.07	-0.06	0.01***
Drugs for intestinal worms given past 6	2350	0.10	1051	0.16	-0.06	0.03**	2326	0.14	1045	0.19	-0.05	0.03*
Did receive VitA dose last 6 months	798	0.19	1047	0.31	-0.12	0.04***	956	0.21	1033	0.30	-0.09	0.04**
Program Outputs/Outcomes												
JMP Improved Sanitation	1512	0.22	996	0.13	0.10	0.04**	1522	0.41	995	0.13	0.28	0.04***
JMP correct child feces disposal	1514	0.18	996	0.14	0.05	0.03*	1525	0.27	996	0.16	0.11	0.03***
Garbage obs. in kitchen or house	1476	0.37	990	0.43	-0.06	0.04*	1491	0.36	994	0.39	-0.03	0.03
No human/animal feces observed in HH living area	1500	0.40	994	0.38	0.02	0.05	1512	0.40	993	0.41	0.00	0.04
Health Status												
diar period prev, last 07 days	2609	0.08	1737	0.12	-0.04	0.02**	2600	0.07	1719	0.13	-0.06	0.01***
diar period prev, last 14 days	2609	0.08	1737	0.15	-0.06	0.02***	2600	0.08	1719	0.15	-0.07	0.02***
alri period prev, last 07 days	2609	0.13	1737	0.10	0.03	0.03	2600	0.16	1719	0.11	0.05	0.03*
alri period prev, last 14 days	2609	0.13	1737	0.11	0.02	0.03	2600	0.17	1719	0.13	0.04	0.03
Child weight (to 0.1 kg) [#]	2161	10.28	943	6.99	3.29	0.16***	2154	10.07	957	7.04	3.03	0.1***
Child height (to 0.1 cm) [#]	2185	82.31	933	68.11	14.21	0.49***	2175	81.68	932	69.43	12.25	0.62***

Description	CONTROL						INTERVENTION					
	Follow-up (F)		Baseline (B)		F-B		Follow-up (F)		Baseline (B)		F-B	
	N	Mean	N	N	Mean	N	N	Mean	N	Mean	Mean	SE
Child arm circ. (to 0.1 cm [#])	2191	13.80	895	12.99	0.82	0.11***	2197	13.78	921	13.01	0.77	0.12***
Weight-for-age z-score [#]	2161	-1.83	943	-2.18	0.35	0.1***	2154	-1.92	957	-2.20	0.28	0.09***
Length/height-for-age z-score [#]	2185	-2.16	933	-1.81	-0.35	0.13***	2175	-2.19	932	-1.38	-0.81	0.20***
Arm Circ-for-age z-score [#]	2191	-1.34	895	-1.33	-0.01	0.11	2197	-1.34	921	-1.31	-0.03	0.11
Weight-for-height z-score [#]	2054	-0.83	879	-1.43	0.60	0.12***	2054	-0.85	895	-1.68	0.83	0.16***
Anemic: Hb < 110 g/l	1922	0.51	331	0.93	-0.42	0.04***	1919	0.56	297	0.88	-0.32	0.04***
Microbiology												
Log ₁₀ (ecoli) in household DW (ecoli in CFU/100 ml)	403	1.40	176	2.06	-0.66	0.08***	404	1.26	178	2.02	-0.76	0.11***
Whether HH DW is contaminated with ecoli	403	0.82	176	0.98	-0.16	0.03***	404	0.77	178	0.96	-0.19	0.03***
Any protozoa infection prevalence ^{&}	569	0.26	88	0.13	0.13	0.04***	581	0.22	93	0.13	0.09	0.04**
<i>Entamoeba histolytica</i> infection prevalence ^{&}	569	0.02	88	0.08	-0.05	0.03*	581	0.03	93	0.09	-0.05	0.03*
<i>Giardia lamblia</i> infection prevalence	569	0.23	88	0.05	0.19	0.03***	581	0.18	93	0.04	0.14	0.03***
Soil transmitted helminth infection prevalence [#]	569	0.06	88	0.06	0.00	0.02	581	0.06	93	0.04	0.02	0.03
Any helminth or protozoa infection prevalence	569	0.31	88	0.18	0.13	0.05**	581	0.27	93	0.17	0.10	0.04**

Z-test was used for the group mean by clustering standard error at village level. The significance is noted as:

* $P < 0.1$ ** $P < 0.05$ *** $P < 0.01$

Table 7. Differences at follow-up between TSC intervention and control groups for main program outputs, outcomes, and impacts

Outputs, Outcomes, Impacts	Control Group			Difference due Intervention				Difference due to Intervention			
				ITT unadjusted				ITT adjusted ¹			
	N	Mean	SE	N	Coeff	SE	R2	N	Coeff	SE	R2
Panel 1: Program Exposure											
Did HH receive WASH mass media message	1511	0.27	0.01	3034	0.023	0.028	0.05	2,972	0.000	0.024	0.14
Did HH change WASH behavior due to mass media	1511	0.18	0.01	3034	0.03	0.026	0.05	2,972	0.019	0.023	0.11
Did HH receive WASH message from personal visits	1472	0.10	0.01	2951	0.140***	0.021	0.07	2,892	0.127***	0.023	0.08
Did HH change WASH behavior due to personal visits	1472	0.06	0.01	2951	0.095***	0.018	0.04	2,892	0.080***	0.018	0.05
Did HH participate or is aware of CLTS Triggering	1514	0.16	0.01	3039	0.135***	0.026	0.07	2,977	0.140***	0.026	0.08
Does HH know of masons to build toilets	1513	0.70	0.01	3038	0.015	0.023	0.08	2,976	0.023	0.026	0.09
Does HH know of shop to buy toilet mater	1514	0.85	0.01	3039	-0.043**	0.019	0.11	2,977	-0.017	0.021	0.13
Does HH know of TSC/NGP	1514	0.21	0.01	3039	0.062**	0.026	0.07	2,977	0.053**	0.025	0.12
Panel 2: Toilet Coverage and Sanitation-related Behavior											
HH with JMP Improved Sanitation	1512	0.22	0.01	3034	0.189***	0.035	0.09	2,972	0.178***	0.035	0.13
Observe that HH is using toilet	1504	0.17	0.01	3024	0.104***	0.029	0.08	2,962	0.093***	0.025	0.15
HH Reported OD by men	1514	0.84	0.01	3039	-0.095***	0.029	0.07	2,977	-0.087***	0.024	0.14
HH Reported OD by women	1514	0.83	0.01	3039	-0.102***	0.028	0.07	2,977	-0.091***	0.025	0.15
HH Reported OD by children	1514	0.89	0.01	3039	-0.053**	0.021	0.04	2,977	-0.054***	0.017	0.11
HH reports JMP correct child feces disposal	1514	0.18	0.01	3039	0.087***	0.021	0.06	2,977	0.075***	0.019	0.10
No human/animal feces observed in HH living area	1500	0.40	0.03	3012	0.006	0.026	0.11	2950	0.019	0.023	0.13
Panel 3: Drinking Water Quality											
Log ₁₀ <i>E. coli</i> in household drinking water (CFU/100 ml)	403	1.40	0.05	807	-0.153*	0.086	0.08	791	-0.046	0.09	0.09
<i>E. coli</i> present in household drinking water, %	403	0.82	0.02	807	-0.055*	0.028	0.05	791	-0.032	0.034	0.05
<i>E. coli</i> present in the source from where household collected drinking water, %	280	0.74	0.03	511	-0.115	0.077	0.14	504	-0.016	0.083	0.20
Panel 4: Intestinal Parasite Infections											
Any protozoan present	569	0.26	0.02	1150	-0.04	0.024	0.03	1,128	-0.027	0.028	0.04
<i>Entamoeba histolytica</i> present	569	0.02	0.01	1150	0.008	0.008	0.02	1,128	0.009	0.009	0.03

Outputs, Outcomes, Impacts	Control Group			Difference due Intervention				Difference due to Intervention			
				ITT unadjusted				ITT adjusted ¹			
	N	Mean	SE	N	Coeff	SE	R2	N	Coeff	SE	R2
<i>Giardia lamblia</i> present	569	0.23	0.02	1150	-0.048**	0.024	0.03	1,128	-0.036	0.026	0.04
Any helminth present	569	0.06	0.01	1150	0.001	0.011	0.02	1,128	-0.005	0.012	0.03
<i>Ascaris lumbricoides</i> present	569	0.04	0.01	1150	-0.002	0.01	0.02	1,128	-0.011	0.01	0.03
Any intestinal parasite present	569	0.31	0.02	1150	-0.040*	0.023	0.03	1,128	-0.032	0.026	0.04
Panel 5: Caregiver reported illness in the last 7 days											
Diarrhea	2609	0.08	0.01	5209	-0.003	0.008	0.02	5,096	-0.002	0.008	0.03
Acute respiratory infection	2609	0.13	0.01	5209	0.038**	0.017	0.06	5,096	0.049**	0.02	0.07
Panel 6: Anemia and Anthropometry											
Anemic: Hb < 110 g/L	1922	0.51	0.01	3841	0.05	0.03	0.10	3,761	0.033	0.032	0.13
Child weight (to 0.1 kg) [#]	2161	10.28	0.06	4315	-0.229*	0.132	0.02	4,239	-0.13	0.108	0.59
Child height (to 0.1 cm) [#]	2185	82.31	0.25	4360	-0.678*	0.344	0.01	4,275	-0.242	0.275	0.75
Child arm circ. (to 0.1 cm [#])	2191	13.80	0.03	4388	-0.004	0.071	0.09	4,294	-0.022	0.073	0.24
Weight-for-age z-score [#]	2161	-1.83	0.03	4315	-0.095	0.079	0.02	4,239	-0.094	0.076	0.05
Length/height-for-age z-score [#]	2185	-2.16	0.04	4360	-0.034	0.081	0.02	4,275	-0.04	0.092	0.08
MUAC-for-age z-score [#]	2191	-1.34	0.02	4388	0.02	0.068	0.10	4,294	-0.022	0.065	0.14
Weight-for-height z-score [#]	2054	-0.83	0.04	4108	-0.018	0.089	0.04	4,035	0.029	0.086	0.05
BMI z-score [#]	2052	-0.60	0.04	4104	-0.062	0.09	0.03	4,030	-0.019	0.087	0.04

Abbreviations. BMI: Body Mass Index; CLTS: Community-Led Total Sanitation; Hb: Hemoglobin; HH: household; ITT: Intention-To-Treat; JMP: WHO/Unicef Joint Monitoring Programme for Water Supply and Sanitation; MUAC: Mid-Upper-Arm Circumference; OD: Open Defecation; WASH: Water, Sanitation, and Hygiene

¹ Adjusted models included: whether household head attended school, whether household belongs to Scheduled Caste or Tribe, percentage of surveyed households in the GP with improved water source at baseline, and percentage of surveyed households in the GP with soap, water present at hand washing place used after defecation, and average height-for-age Z-score in the GP at the baseline. For child level outcomes, age of child in months and sex were also included.

* $P < 0.1$ ** $P < 0.05$ *** $P < 0.01$

Table 8. Differences at follow-up between TSC intervention and control groups stratified by population subgroups

	Control			Intervention			ITT - Unadjusted				ITT – Adjusted ¹			
	N	Mean	SE	N	Mean	SE	N	Coeff	SE	R2	N	Coeff	SE	R2
HH with JMP Improved Sanitation														
Total Population	1512	0.22	0.01	1522	0.41	0.01	3034	0.189***	0.035	0.09	2972	0.178***	0.035	0.13
No toilet at Baseline	1319	0.11	0.01	1297	0.32	0.01	2616	0.202***	0.031	0.11	2564	0.193***	0.033	0.11
Toilet at Baseline	190	0.98	0.01	212	0.97	0.01	402	-0.018	0.019	0.05	392	0.008	0.014	0.07
BPL	375	0.17	0.02	300	0.48	0.03	675	0.317***	0.046	0.16	660	0.330***	0.054	0.18
Non-BPL	1137	0.24	0.01	1222	0.4	0.01	2359	0.152***	0.037	0.09	2312	0.137***	0.035	0.13
Observe that HH is using toilet														
Total Population	1504	0.17	0.01	1520	0.27	0.01	3024	0.104***	0.029	0.08	2962	0.093***	0.025	0.15
No toilet at Baseline	1311	0.06	0.01	1294	0.17	0.01	2605	0.108***	0.021	0.07	2553	0.097***	0.02	0.08
Toilet at Baseline	190	0.91	0.02	212	0.89	0.02	402	-0.026	0.029	0.1	392	-0.01	0.027	0.14
BPL	373	0.08	0.01	300	0.29	0.03	673	0.228***	0.034	0.15	658	0.228***	0.037	0.18
Non-BPL	1131	0.2	0.01	1220	0.27	0.01	2351	0.065**	0.031	0.08	2304	0.053*	0.027	0.15
HH Reported OD by men														
Total Population	1514	0.84	0.01	1525	0.75	0.01	3039	-0.095***	0.029	0.07	2977	-0.087***	0.024	0.14
No toilet at Baseline	1320	0.95	0.01	1297	0.85	0.01	2617	-0.096***	0.019	0.06	2565	-0.089***	0.018	0.07
Toilet at Baseline	191	0.12	0.02	214	0.13	0.02	405	0.008	0.038	0.1	395	0.006	0.035	0.18
BPL	375	0.93	0.01	300	0.74	0.03	675	-0.197***	0.032	0.12	660	-0.198***	0.035	0.16
Non-BPL	1139	0.81	0.01	1225	0.75	0.01	2364	-0.062*	0.032	0.07	2317	-0.054**	0.026	0.15
HH Reported OD by women														
Total Population	1514	0.83	0.01	1525	0.73	0.01	3039	-0.102***	0.028	0.07	2977	-0.091***	0.025	0.15
No toilet at Baseline	1320	0.94	0.01	1297	0.84	0.01	2617	-0.101***	0.02	0.07	2565	-0.092***	0.019	0.08
Toilet at Baseline	191	0.1	0.02	214	0.1	0.02	405	0	0.039	0.12	395	0.001	0.034	0.20
BPL	375	0.92	0.01	300	0.73	0.03	675	-0.206***	0.033	0.13	660	-0.206***	0.035	0.16
Non-BPL	1139	0.81	0.01	1225	0.73	0.01	2364	-0.068**	0.032	0.07	2317	-0.057**	0.027	0.16
HH Reported OD by children < 5 y														
Total Population	1514	0.89	0.01	1525	0.84	0.01	3039	-0.053**	0.021	0.04	2977	-0.054***	0.017	0.11
No toilet at Baseline	1320	0.96	0.01	1297	0.91	0.01	2617	-0.055***	0.012	0.03	2565	-0.054***	0.011	0.04
Toilet at Baseline	191	0.41	0.04	214	0.42	0.03	405	0.044	0.064	0.11	395	-0.043	0.077	0.17
BPL	375	0.97	0.01	300	0.83	0.02	675	-0.139***	0.024	0.1	660	-0.141***	0.025	0.11
Non-BPL	1139	0.87	0.01	1225	0.84	0.01	2364	-0.025	0.025	0.04	2317	-0.028	0.019	0.12
Diarrhea in the past 7 days														
Total Population	2609	0.08	0.01	2600	0.07	0.01	5209	-0.003	0.008	0.02	5096	-0.002	0.008	0.03
No toilet at Baseline	2302	0.08	0.01	2231	0.08	0.01	4533	0.001	0.009	0.02	4435	0.003	0.009	0.03

	Control			Intervention			ITT - Unadjusted				ITT – Adjusted ¹			
	N	Mean	SE	N	Mean	SE	N	Coeff	SE	R2	N	Coeff	SE	R2
Toilet at Baseline	302	0.06	0.01	343	0.03	0.01	645	-0.034*	0.019	0.04	630	-0.037	0.023	0.06
BPL	638	0.09	0.01	513	0.08	0.01	1151	-0.007	0.015	0.03	1120	-0.002	0.017	0.05
Non-BPL	1971	0.07	0.01	2087	0.07	0.01	4058	0	0.009	0.02	3976	0	0.011	0.03
<i>Ascaris lumbricoides</i> infection														
Total Population	569	0.04	0.01	581	0.04	0.01	1150	-0.002	0.01	0.02	1128	-0.011	0.01	0.03
No toilet at Baseline	487	0.05	0.01	482	0.04	0.01	969	-0.004	0.01	0.01	950	-0.013	0.01	0.03
Toilet at Baseline	82	0.04	0.02	92	0.04	0.02	174	-0.004	0.02	0.09	171	-0.005	0.041	0.14
BPL	147	0.07	0.02	109	0.04	0.02	256	-0.019	0.03	0.08	250	0.007	0.042	0.11
Non-BPL	422	0.04	0.01	472	0.04	0.01	894	0.007	0.01	0.02	878	-0.009	0.01	0.03
<i>Giardia lamblia</i> infection														
Total Population	569	0.232	0.022	581	0.184	0.018	1150	-0.048**	0.024	0.03	1128	-0.036	0.026	0.04
No toilet at Baseline	487	0.232	0.023	482	0.185	0.02	969	-0.041	0.026	0.03	950	-0.036	0.029	0.04
Toilet at Baseline	82	0.232	0.04	92	0.185	0.054	174	-0.115**	0.053	0.18	171	-0.06	0.073	0.23
BPL	147	0.224	0.037	109	0.165	0.036	256	-0.045	0.048	0.08	250	-0.062	0.057	0.12
Non-BPL	422	0.235	0.023	472	0.189	0.021	894	-0.050*	0.027	0.03	878	-0.037	0.029	0.05
Weight-for-age z-score[#]														
Total Population	2161	-1.83	0.03	2154	-1.92	0.03	4315	-0.095	0.079	0.02	4239	-0.094	0.076	0.05
No toilet at Baseline	1909	-1.87	0.03	1854	-1.95	0.03	3763	-0.104	0.085	0.02	3699	-0.103	0.08	0.05
Toilet at Baseline	247	-1.56	0.09	275	-1.68	0.07	522	-0.132	0.134	0.05	510	-0.086	0.134	0.07
BPL	551	-2	0.06	441	-1.95	0.07	992	0.034	0.121	0.05	972	0.033	0.121	0.08
Non-BPL	1610	-1.78	0.04	1713	-1.91	0.03	3323	-0.143*	0.081	0.02	3267	-0.132*	0.079	0.05
Length/height-for-age z-score[#]														
Total Population	2185	-2.16	0.04	2175	-2.19	0.04	4360	-0.034	0.081	0.02	4275	-0.04	0.092	0.08
No toilet at Baseline	1928	-2.19	0.04	1873	-2.23	0.04	3801	-0.054	0.08	0.03	3727	-0.05	0.084	0.09
Toilet at Baseline	253	-1.86	0.11	281	-1.88	0.1	534	0.068	0.184	0.03	523	0.004	0.27	0.05
BPL	549	-2.22	0.08	439	-2.25	0.08	988	-0.01	0.143	0.05	963	0.057	0.16	0.12
Non-BPL	1636	-2.13	0.04	1736	-2.17	0.04	3372	-0.034	0.079	0.02	3312	-0.046	0.09	0.08

Abbreviations. BPL: Below Poverty Line; HH: household; ITT: Intention-To-Treat; JMP: WHO/Unicef Joint Monitoring Programme for Water Supply and Sanitation; OD: Open Defecation

1 Adjusted models included: whether household head attended school, whether household belongs to Scheduled Caste or Tribe, percentage of surveyed households in the GP with improved water source at baseline, percentage of surveyed households in the GP with soap, water present at hand washing place used after defecation, and average height-for-age Z-score in the GP at the baseline. For child level outcomes, age of child in months and sex were also included.

* $P < 0.1$ ** $P < 0.05$ *** $P < 0.01$