Increasing latrine use in rural Karnataka, India using the risks, attitudes, norms, abilities, and self-regulation approach: A cluster-randomized controlled trial

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Abstract

Recent years have seen unparalleled efforts by the Swatchh Bharat Mission (SBM) to make India open defecation free. While latrine coverage has been boosted very successfully, latrine use has remained low in many areas of the country. Consequently, the aim of this study was to use robust psychological theory to develop and rigorously evaluate low-cost and scalable behaviour change interventions to promote latrine use in rural India.

This study reports findings from a cluster-randomized controlled trial (N=1945) conducted in rural Karnataka, India, from January 2017 to February 2019. The evaluated behaviour change interventions were developed using the risks, attitudes, norms, abilities, and self-regulation (RANAS) approach.

Results showed that latrine use changed by more than 15% in both treatment and control arms. The intervention triggered an additional, statistically significant increase in latrine use of approximately 5% to reach 97% use at endline.

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The results suggest that external factors had a strong influence on latrine use, with intensive efforts by SBM likely to be among these. The added value of the campaign was to increase latrine use to almost complete uptake and to successfully tackle the most change-resistant individuals. This intervention or selected components could complement future latrine use promotion in India.

Introduction

The impact of inadequate sanitation on health and wellbeing, especially of children under five, is a global concern (Spears and Lamba 2015; Spears 2013; Clasen et al 2014; Vyas et al 2016). The Sustainable Development Goals (SDGs) list clean water and sanitation as a critical Goal (SDG 6). Basic sanitation includes the use of improved toilet facilities that are not shared with other households (WHO and UNICEF, 2017). This concept involves two essential components: the presence of safe sanitation infrastructure at household level and the behavioural component of toilet use.

In India, 550 million people were defecating in the open in 2014, the highest number for any country in the world (WHO and UNICEF, 2017). Since then, India has made significant progress; the country is poised to declare itself open defecation free in October 2019, following five years of the Swachh Bharat Mission (SBM) sanitation campaign. SBM built upon previous sanitation campaigns such as the Total Sanitation Campaign (1999-2011) and Nirmal Bharat Abhiyan (2012-2014), and it received high-level political support unmatched by its predecessors. SBM's efforts have resulted in the construction of approximately 100 million latrines across rural and urban India in just five years. According to the SBM information monitoring system, 99.76% of households had individual latrines in July 2019, a 61% increase since 2014 (Government of India. Department of Drinking Water and Sanitation. Swachh Bharat Mission- Gramin Monitoring Information System, 2019). SBM's efforts included provision of incentives, engagement of households, communities, and local government in toilet construction and monitoring, and intensive mass media campaigns (Dalberg and Wash Institute, 2019). While the latest national annual rural sanitation survey, conducted in 2018-2019, found high rates of latrine usage reported among households with latrines (96.5%, Kantar Public and IPE Global, 2019), another study conducted in 2018 found a lower usage rate of 56.0% (Gupta et al.,

2019), indicating challenges to usage despite high latrine coverage and to reliable measurement of latrine use.

Garn et al. (2017) examined studies that assessed the impact of sanitation interventions on coverage and use in low- and middle-income countries worldwide. They concluded that the vast majority of sanitation interventions had only a modest impact on coverage and usage outcomes. Behavior change has been identified to be an important success factors for sanitation systems (Davis et al., 2019). De Buck et al. (2017) compared four behaviour change approaches to promote sanitation behaviour: 1) community-based approaches; 2) social marketing approaches; 3) sanitation and hygiene messaging; and 4) elements of psychosocial theory. However, the limited number of studies available did not allow robust comparison of the approaches' effectiveness in changing behaviour and underlying mindsets. The review noted that the presence of sanitation infrastructure alone was insufficient to encourage use, and that behaviour change approaches were critical to promoting latrine use. Cross-sectional evidence from India indicates the importance of factors underlying toilet use, in addition to subsidies (Sinha et al., 2017, Routray et al., 2015, Novotný et al., 2018). Overall, the evidence suggests that the existing interventions did not achieve drastic changes in latrine use and that how to do so most effectively remains largely unknown.

Researchers have proposed several approaches to designing interventions for promoting latrine use. These include community-led total sanitation (CLTS, Kar, 2003), the risks, attitudes, norms, abilities, and self-regulation (RANAS) approach (Mosler, 2012), the integrated behavioural model for water sanitation and hygiene (IBM-WASH, Dreibelbis et al., 2013), behaviour-centred design (Aunger and Curtis, 2016) and an approach that uses nudging and habit change (Neal et al., 2016). To our knowledge, however, the only approach whose effects have been evaluated in India is CLTS (Pattanayak et al., 2009).

We used the RANAS approach because it systematically tailors behaviour change interventions to the mindset of the target population. The RANAS approach has been demonstrated to be useful in

promoting water (Inauen and Mosler, 2013, Huber et al., 2014), sanitation (Mosler et al., 2018, Harter et al., 2018, Mosler and Sonego, 2017), and hygiene behaviours (Contzen et al., 2015, Friedrich et al., 2018). The model describes five blocks of psychological factors: (1) Risk factors concern the perceived vulnerability and perceived severity of contracting a disease and health knowledge about the possibility of being affected by a potential contamination. (2) Attitude factors comprise beliefs about the costs and benefits of the targeted behaviour and feelings that arise when thinking about or performing the behaviour. (3) Norm factors include social influences: the perception of how many others perform the behaviour already, how much others approve or disapprove of this behaviour, and its personal importance (The perception of what is morally right and wrong). (4) Ability factors characterize how-to-do knowledge (i.e., knowing how to perform the behaviour) and the confidence to perform, maintain, and recover a behaviour once stopped. (5) Self-regulation factors help in dealing with conflicting goals or distractions during behaviour implementation and maintenance. Additionally, the RANAS model contains behaviour change techniques (BCTs), which are known to be able to change the behavioural factors. Information BCTs act on the risk factors, persuasion BCTs affect the attitude factors, norm BCTs work on the norm factors, infrastructural, skill, and ability BCTs act on the ability factors, and planning and relapse prevention BCTs affect self-regulation factors. In all, the RANAS model includes 36 BCTs that work on specific behavioural factors.

Taken together, behaviour change interventions based on the RANAS approach promise to narrow the gap between latrine coverage and use in rural India. The RANAS approach has been successful in promoting a wide range of sanitation and hygiene behaviours worldwide but has not been systematically evaluated in India. The aim of this study is to develop a RANAS intervention to promote latrine use in India and rigorously evaluate the value it adds to the intensive efforts to promote latrine use and construction through SBM.

Method

We conducted a cluster-randomized controlled trial with one intervention arm and one nonintervention control arm. The trial was conducted in all five administrative blocks of Raichur District in the south Indian state of Karnataka from January 2018 to March 2019. The clusters of the trial were randomly selected villages in the district.

This study was approved by the institutional review board at the Faculty of Arts, University of Zurich. It was registered at the German Clinical Trials Register under ID DRKS00013537 and at the Registry for International Development Impact Evaluations under ID 5a940c231baef. The trial is reported according to the Consort 2010 statement extension to cluster-randomized controlled trials (Campbell et al., 2012).

Two changes were implemented to the study protocol after the trial had started. First, an advantage inherent to the RANAS approach to systematic behaviour change (Mosler, 2012, Mosler and Contzen, 2016) is that interventions are designed using data about the target audience collected during the baseline survey. Thus, the content of the intervention was finalized only after the baseline survey had been conducted. Second, villages in which all households reported complete latrine use at baseline were excluded from the trial.

Participants

Villages with at least 30% latrine coverage and at least 20 households owning a latrine were eligible for the study. Indian government data (Ministry of Drinking Water and Sanitation, 2018) identified 250 villages out of a total of 1071 villages in Raichur district that met these criteria. Of these, 120 villages were randomly selected. To minimize spill-over from the intervention to the control, villages that were closer than five kilometres from another village or from the same gram panchayat, a type

of village council, as another village were excluded. The location of study villages is presented in Figure 1.

Figure 1: Map of Raichur district and its five administrative blocks.

A census survey was conducted in all 120 selected villages, to identify basic socio-demographic characteristics and latrine ownership of all households. Households with a functional household latrine, defined as having at least a pit and a pan, were eligible for the study. In each household, one survey respondent aged at least 18 years was randomly selected. If the designated survey respondent was ineligible, a back-up participant was selected. The data collection agency was instructed that main respondents needed to be surveyed in at least 50% of households.

Intervention

The intervention was designed according to the RANAS approach (Mosler, 2012, Mosler and Contzen, 2016). First, the behavioural factors steering latrine use in the study population were identified through cross-sectional formative analyses of the baseline data of this trial. Based on these analyses, one or several BCTs were selected from the RANAS catalogue of BCTs to change the behavioural factors identified. The project partners used creative workshops to design the specific implementations of the BCTs and combine them into three intervention strategies. The intervention matrix in Table 1 provides an overview of the behavioural factors identified, the BCTs to change them, and the activities for implementing the BCTs. Strategy 1 of the campaign pertained to cluster level, while Strategies 2 and 3 pertained to household level. The intervention protocols are specified in the supplementary information.

The intervention was implemented by the Swami Vivekananda Youth Movement, an organization well versed in implementing WASH interventions, in the district between May and November 2018. The implementation staff comprised 14 promoters (four women and 10 men), two supervisors, and a coordinator. They received rigorous training on the RANAS approach and intervention implementation to carry out the intervention in a standardized manner in all of the villages. The staff

undertook two rounds of rigorous intervention protocol pretesting of all three strategies in nontrial villages.

To deliver the intervention, a pair of promoters were assigned to each village. On the first day, the pair visited the village, met representatives, such as gram panchayat members, village health promoters, and other village-level leaders, and scheduled the village meeting (Strategy 1). They spent the rest of the day mobilizing for the village meeting. Supported by these two promoters, a team of three members, comprising two promoters specifically trained for the village meetings and one technician, conducted the meeting. Over the next few days, the promoters carried out the first round of household visits (Strategy 2). The second round of household visits and the phone calls (Strategy 3) were carried out in such a way that the interval between the activities was at least 3 days for each household. On average, the intervention was delivered in a village within 7 to 8 days.

Table 1: Intervention matrix.

Outcomes

This study had two primary outcomes: First, self-reported household latrine use, termed *latrine use.* Second, an observation index of signs of latrine use measured through spot-check observations of the latrine, termed *latrine observation index.* Both outcomes pertained to household level.

Baseline data were collected from March to April 2018 with a team of 20 data collectors and 5 supervisors. Endline data were collected from January to March 2019 with a team of 14 data collectors and 7 supervisors. The questionnaire was administered in the local language, Kannada. Latrine use of all household members of at least five years of age was surveyed using the following item in a household roster: “The last time [NAME] defecated, did [NAME] defecate in the open or use the latrine?”. The response options were “In the open”, “In the latrine” and “Somewhere else”. For each household member, defecation in the latrine was coded as 1 and defecation in the open or somewhere else was coded as 0. Household latrine use was computed by taking the mean across all household members and multiplying it by 100. This yielded a scale ranging from 0%, meaning that all

household members defecated in the open or somewhere else than in the latrine, to 100%, meaning that all household members defecated in the latrine.

Spot-check observations of the latrine were performed at the end of the household visit and included seven items, which are presented in Table 2. Response options to all items were “yes” and “no”.

Table 2: spot-check items.

Spot-check items were aggregated to an index by computing the mean of all items and multiplying it with 100. A value of 0% meant that all spot-check observations suggested that the latrine was unused, and a value of 100% meant that all spot-check observations suggested that the latrine was being used. Items marked with an asterisk in Table 2 were reverse-coded when computing the index.

The questionnaire and spot-check items were intensively pretested. Before each wave of data collection, the team underwent one week of intensive theoretical and practical training. Data collectors were introduced to the project objectives and structure and to the basic concepts of the RANAS approach. Each questionnaire section was explained, then rehearsed as a role play in front of the team, and finally, data collectors practiced the interview in mock interviews with each other. Over two days, data collectors conducted partially accompanied interviews in non-trial villages in the morning and attended debriefing sessions in the afternoon. The data collected during these days were discarded.

A solid monitoring plan was devised through a carefully planned team structure and a responsive system for constant monitoring and quality control. Every team comprised one supervisor and four data collectors. The supervisor was tasked with accompanying interviews and back-checks to check the quality of data collection. Interviews were accompanied periodically by the supervisors. Based on observations made while their interviews were accompanied, the data collectors were debriefed directly after the visits to improve their performance in the subsequent interviews.

Sample size

The sample size was calculated using G*Power 3.1.9.2. Aiming to achieve a minimal detectable effect size of 10% increase in latrine use with an alpha probability of .05, a statistical power of .8, and a cluster size of 15 households per villages and assuming 50% latrine use at baseline, an intracluster correlation coefficient (ICC) of .25, take-up rates of the intervention of 95% and attrition of 25% yielded a required sample size of 2400 households across 120 villages. Actual baseline data yielded a mean latrine use of 79.0 % (SD=35.6) with an ICC of 0.202. Using these values yielded a minimal sample size of 1221 households across 81 villages. After baseline, we decided to remove 10 villages from the study, because they had reported 99% or 100% latrine use at baseline. We decided to retain all other villages in the study to achieve maximum possible statistical power. A final sample of 1945 participants from 110 clusters was analysed throughout this study.

Randomization

Participants were allocated to treatment or control arms at village level. A pair-matched randomized design was used, with each village's average baseline latrine use serving as matching variable. First, baseline latrine use of all household members was computed for each village. Second, the two villages whose latrine use was most similar were paired. Third, a random number was computed for each village using Microsoft Excel's Rand() function. Finally, in each pair, the village with the higher number was allocated to the control arm and the village with the lower number was allocated to intervention. The evaluation design and flowchart of the sample are presented in Figure 2.

The first author generated the random numbers, enrolled clusters, and assigned clusters to intervention or control arms. Participants were included in clusters based on their village of residence since the clusters of the study were villages. Informed oral consent was obtained from the main respondent of each household before conducting the baseline interview. Since data collectors saw the intervention material in the villages during the endline survey, blinding was not possible.

Figure 2: Flow-chart of the sample.

Statistical Methods

We report intention-to-treat effects throughout this study. This means that all baseline participants that were recovered at endline, irrespective of intervention participation, were included in the analyses. We chose this design to maintain the random selection of participants.

Three preliminary analyses were conducted to assess the internal validity of the trial. First, to determine whether allocation to study arms was balanced, we computed socio-demographic characteristics of participants and baseline values of the outcomes separately for each study arm. Second, to demonstrate that attrition from the study was nonsystematic, descriptive statistics of socio-demographics and outcomes at baseline were computed separately for those participants who dropped out of the study and those who remained in the study. Third, to crosscheck the extent to which interventions had reached the intended participants, we checked self-reported participation in intervention activities and observed presence of intervention materials in the households at endline. For preliminary analyses, statistical significance was not estimated, as these additional tests would have required additional statistical power. All analyses were conducted using SPSS 24.

To assess whether the intervention had statistically significantly increased study outcomes, we computed multilevel linear models using the following specification:

$$Y_{ij} = (b_0 + u_{0j}) + b_1X_{ij} + b_2Z_{ij} + b_3Z_{ij}*X_{ij}+\varepsilon_{ij}$$

Y_{ij}: change in outcome for household i, in village j

b_0: fixed intercept

u_{0j}: deviation from fixed intercept in village j

b_1: fixed effect of the treatment

X_{ij}: treatment condition of household i in village j

Z_{ij}: baseline value of outcome for household i in village j

ε_{ij}: error of household i in village j

Adding random slopes to the models resulted in redundant covariance estimates and did not statistically significantly improve the model fit. Thus, random slopes were not included. Since the research question examines a direct effect, *p*-values of .1 needed to be considered statistically significant if testing a single outcome. Correcting for testing of multiple outcomes using Benjamini and Hochberg's (1995) procedure indicated that the lowest *p*-value would need to be lower than 0.033 and *p*-value of the other outcome would need to be lower than .067 to be considered statistically significant.

Results

Socio-demographic characteristics and baseline values of outcomes are presented in Table 3. The data suggest a balanced allocation of participants to intervention and control arms for all variables.

Table 3: Socio-demographic characteristics and baseline values of outcomes in the control and treatment arms.

The results of drop-out analyses are presented in Table 4. The socio-demographics show slight differences in the age of respondents, with drop-outs being about 2 years younger, and caste affiliation, with a 3 percentage points higher share of scheduled caste (SC), scheduled tribe (ST), and other backward class (OBC) households among the drop-outs.[1] The outcomes indicate that drop-outs had reported 4 percentage points lower latrine use at baseline. Considering the low number of drop-outs, these differences are very unlikely to be statistically significant.

Table 4: Socio-demographic characteristics and baseline values of outcomes for drop-outs and participants included in analysis.

The findings from the intervention check are reported in Table 5. For the village meeting, 73% of households reported that at least one household member had participated in the meeting. This is corroborated by observation of distributed handouts in 64% of intervention households. At least one piece of the intervention material was observed in almost 80% of households at follow-up, and roughly 70% of households reported having received the phone call.

Table 5: Manipulation check.

The main analysis yielded that both latrine use and the latrine observation index increased throughout the study arms (Figure 3). In the intervention arm, latrine use increased by 19.57 percentage points (SD=39.39) from 77.54% (SD=36.26) at baseline to 97.10% (SD=15.31) at endline.

[1] Scheduled castes, scheduled tribe and other backward classes refer to historically disadvantages groups in the Indian caste system.

However, in the control arm latrine use also increased substantially, by 15.02 percentage points (SD=44.11) from 77.40% (SD=36.51) at baseline to 92.42% (SD=24.92) at endline. The increase in the intervention arm was 4.55 percentage points higher than the increase in the control arm. A similar trend was observed for the latrine observation index; in the intervention arm, the index increased by 13.08 percentage points (SD=32.84) from 68.17% (SD=28.17) to 81.25% (SD=18.45), and in the control arm, it increased by 6.80 percentage points (SD=34.43) from 70.37% (SD=26.76) to 77.18% (SD=22.99). The increase in the intervention arm was 6.26 percentage points higher than the increase in the control arm.

Figure 3: Baseline, endline, and change values and differences in difference of latrine use (left) and observation index (right).

A multilevel linear model that accounted for clustering at village level, with changes in household latrine use as dependent variable and intervention arm, baseline latrine use, and the interaction of the two as independent variables, revealed a statistically significant positive effect of the intervention on latrine use: $b = 6.95$, $t(192.76) = 2.14$, $p = .034$. Baseline values of latrine use showed negative model effects, $b = -0.99$, $t(1883.76) = -64.18$, $p < .000$, indicating that households with high latrine use at baseline reported smaller changes in latrine use than households with low latrine use at baseline. The interaction effect of baseline latrine use and intervention condition was not significant; $b = -0.03$, $t(1885.92) = -1.22$, $p = .223$, suggesting that baseline values had a similar effect in both study arms. The model showed significant variance in intercepts across households, $var(u_{0j}) = 200.87$, meaning that overall levels of latrine use differed between villages. As compared to the fixed effect model (-2LL = 17290.89), adding a random intercept statistically significantly improved the model fit, $\chi^2(1) = 782.94$, $p < .01$.

A multilevel linear model that accounted for clustering at village level, with changes in the latrine observation index as dependent variable and intervention arm, baseline observation index, and the interaction of the two as independent variables, revealed a statistically significant positive effect of

intervention arm on the observation index, b = 7.86, t(290.51) = 2.37, p =.018. Baseline values showed negative effects, b = -0.94, t(1888.81) = -42.45, p < .000, indicating that households with a high index at baseline showed smaller changes than households with a lower index at baseline. The interaction effect of baseline latrine observation index and intervention condition was not significant; b = -0.04, t(1898.79) = -1.46, p = .144, suggesting that baseline values had a similar effect in both study arms. The model showed significant variance in intercepts across households; var(u_{0j}) = 161.55, meaning that overall levels of the latrine observation index differed between villages. As compared to the fixed effect model (-2LL = 17326.46), adding a random intercept statistically significantly improved the model fit, $\chi^2(1) = 567.12$, $p < .01$.

Discussion

In this study, we establish that theory-based behaviour change interventions designed using the risks, attitudes, norms, abilities, and self-regulation (RANAS) approach were effective in changing latrine use behaviour. We conducted a pair-matched cluster-randomized controlled trial to test one such intervention in 110 villages of rural Karnataka. Results revealed that self-reported latrine use changed substantially in both treatment and control arms. The intervention statistically significantly increased latrine use by 5 percentage points more than the control and resulted in 97% latrine use at endline. This modest yet significant additional effect of the intervention on latrine use is corroborated by the significant effects of similar magnitude on observed signs of latrine usage.

These effects were considerably smaller than in previous randomized controlled trials evaluating the effects of sanitation interventions on latrine use in India (Garn et al., 2017). For instance, intention-to-treat effects on latrine use of a CLTS campaign focusing on latrine construction in Orissa were 27% among men and 23% among women (Pattanayak et al., 2009). Intention-to-treat effects found by an evaluation study of the total sanitation campaign in Madhya Pradesh were 10% (Patil et al., 2014). Among households that had a functional latrine at endline, use was 13% higher in the intervention arm than in the control arm. More recently reported impact assessments, which were also conducted while SBM was ongoing, revealed considerably smaller (Caruso et al., 2019) or null effects (Viswanathan et al., 2019, Chauhan et al., 2019). However, the small effects revealed in this study require a robust explanation.

First, considering the baseline values of this study reveals that latrine use before the trial started was 77%, and thus was already high. The potential for the intervention to increase latrine use was thus limited. Second, taking the absolute values at endline into account shows that latrine use after the intervention in the present study amounted to 97%. This suggests that, unlike previous studies, the

intervention effects were constrained by a ceiling effect. In Patil et al.'s study the (2014) study, for instance, latrine use was substantially lower, amounting to only 41% among households having an improved latrine. Taken together, the existing situation at trial start, substantial changes in both the intervention and control arms, and a likely ceiling effect limited the effects of the intervention.

Our findings can be interpreted effectively with diffusion of innovation theory (Rogers, 2010). This theory postulates a temporal sequence in which five different types of individuals, each characterized by specific traits, adopt an innovation, in our case latrine use. The theory distinguishes innovators, early adopters, early majority, late majority, and laggards, this last constituting the final 16% of a population, to adopt an innovation and being characterized by social isolation and critical attitudes towards change. A study examining latrine construction found laggards to have distinct characteristics in behavioural factors (Slekiene and Mosler, 2018). Consequently, the intervention's effect in increasing latrine use to 97%, compared to 92% in the control, suggests that the intervention was particularly effective in promoting latrine use among laggards, the most change-resistant and isolated of the five groups. This is particularly relevant given the difficulties to benefiting this group through existing sanitation interventions (Ezbakhe et al., 2019). Evaluation studies reported usage levels after interventions of 41% (Patil et al., 2014), 80% (Caruso et al., 2019), 91% (Chauhan et al., 2019) and 81% (Viswanathan et al., 2019).

Reaching the laggards and effectively promoting complete or almost complete latrine use may be crucial to improving the health of communities. The health impact of sanitation interventions remains uncertain, and recent field experiments have cast further doubt on it (Stewart et al., 2018, Tofail et al., 2018, Humphrey et al., 2019). One potential explanation of the repeated null effects on health outcomes of these studies, despite observational findings suggesting health impacts of safe sanitation, is that they did not trigger sufficient behaviour change to produce substantial health effects. We do not know the exact proportion of a village or community that has to adopt latrine use

to achieve a health gain. However, if health effects can be produced by latrine use, achieving almost complete latrine use, as in this study, has the highest potential to deliver them.

The findings of this study must be understood in the context of the Swachh Bharat Mission (SBM). A recent study estimated that an Indian rural resident was exposed to 2500–3300 SBM-related messages, on average, between 2014 and 2019 through interpersonal communication, ambient media, mass media, cinema and digital media (Dalberg and Wash Institute, 2019). The Karnataka Government intended to declare open-defecation-free status in November 2018, and consequently, SBM campaign activities reportedly intensified from June 2018 onwards, coinciding with the implementation of this study's intervention. To understand the potential effects of SBM on this impact assessment, the study team conducted a qualitative inquiry in both intervention and control villages that focused on 1) SBM activities promoting latrine use, and 2) repeated measurements related to sanitation. Details of the qualitative study findings are provided in the appendix; we summarize certain critical insights here.

As expected, toilet construction intensified in Raichur in 2018, and latrine use promotion activities were conducted during the intervention period; these included frequent household visits, routine monitoring of latrines and their functioning, local surveillance committees observing open defecation fields, street plays, and mothers' meetings in anganwadis (early child care and education centres). The salient message communicated through these activities related to the importance of latrines in preventing disease and their convenience of use. Community stakeholders also mentioned increasing social pressures towards latrine use, for example through surveillance of defecation places and latrine checks for signs of use. The likely effects of these activities on this trial are threefold: First, these efforts probably triggered substantial increases in actual latrine use in both the intervention and the control arms. Second, the promotion activities probably resulted in latrine use being perceived as highly socially desirable and potentially led individuals to over-report their latrine use. Third, various forms of monitoring and surveys assessing open defecation and latrine

construction and status may have introduced a repeated measurement bias that led to further over-reporting of latrine use. In summary, SBM activities thus probably led to both a genuine increase in latrine use and over-reporting of the same. In the absence of a factorial study design, these effects cannot be fully disentangled.

Implications and limitations

The SBM is set to embark on its second phase after October 2019. The Government of India's Department of Drinking Water and Sanitation has identified ODF Sustainability as one of the four core components of this phase. Under ODF Sustainability, the Government has underscored continuous behaviour change communication as a focus area, to ensure sustained and regular toilet use. For states and districts in India that want to consolidate and enhance the benefits gained under SBM in the ODF Plus phase, the RANAS approach provides a useful framework for developing and implement a latrine use campaign in a systematic and focused manner, targeting the psychosocial factors that underlie latrine use. On closer examination of SBM activities, the study team noted that SBM activities do address some of the psychosocial factors also targeted by the RANAS intervention, though the manner in which they trigger change in these factors differs from the RANAS intervention. For instance, SBM addresses norm factors in a powerful manner through vigilance activities and public disapproval that discourage open defecation, whereas this study's intervention addressed them through public commitment. While evidence is lacking as to which strategy is more effective in changing the behavioural factors underlying latrine use, SBM can incorporate RANAS behaviour change techniques to sustain the improvements in latrine use that SBM has brought about during the first phase and to reach the most change-resistant individuals still practising open defecation. More specifically, the findings from this study can be added to a compendium of behaviour change strategies, communication, and training material. The National and State Governments in India can then select from this compendium to meet the needs of particular contexts, sanitation coverage and usage, and barriers to adoption. The Ranas approach may be applied effectively in other countries beyond India to promote latrine use and other sanitation

behaviours. It's inherent characteristic of, first, systematically determining the psychosocial factors steering a behaviour and, second, developing the interventions based on this understanding is promising to provide context specific interventions wherever they are most needed.

This study has important limitations and recommendations for further sanitation trials. First, the evaluation is primarily based on self-reports and reports. Although the increases detected in latrine use are consistent with spot-check observations, the latter give little information about the frequency with which latrines are used; they only offer a household-level proxy of whether the latrine is used at all. However, changes in spot-check observations and self-reported latrine use behaviour were similar. Second, we did not quantitatively capture factors external to this study, such as SBM activities promoting and measuring latrine use. While these factors are likely to have influenced latrine use, they are unlikely to have biased the difference in study outcomes between intervention and control arm because both intervention and control villages would have been subjected to them equally. Alternatives to self-reports for measuring latrine use would substantially strengthen our understanding of the interventions. While observations and sensor-based methods (Clasen et al., 2012) may pose financial and ethical challenges, survey-based methods concealing the individual behaviour of respondents may be an economical and effective way to measure latrine use (see Nuno and John (2015), for examples). When conducting further studies with ongoing large-scale sanitation programs, such as the SBM, using a full factorial design to assess the effects of the external program and the additional intervention would allow them to be disentangled experimentally. Alternatively, explicit quantitative measures of the dose of external activities might complement a two-armed trial, like ours, and provide a more robust understanding of potential external effects.

Conclusions

This study reveals that theory-based interventions using the RANAS approach effectively complemented ongoing efforts to make India open defecation free by triggering modest but

significant additional behaviour change. The intervention may help promote latrine use in two ways: First, the intervention may be applied to prompting the most change-resistant individuals to adopt latrine use. Second, individual components of this campaign may be selected to fit the mindset of specific target populations in future sanitation campaigns. It will be critical to study ongoing large-scale interventions to examine which of the relevant behavioural factors have already been targeted and which behavioural factors can be further leveraged to strengthen these interventions. This approach can also be applied to other projects that aim to change behaviours that are shaped and driven by deep-set psychosocial factors.

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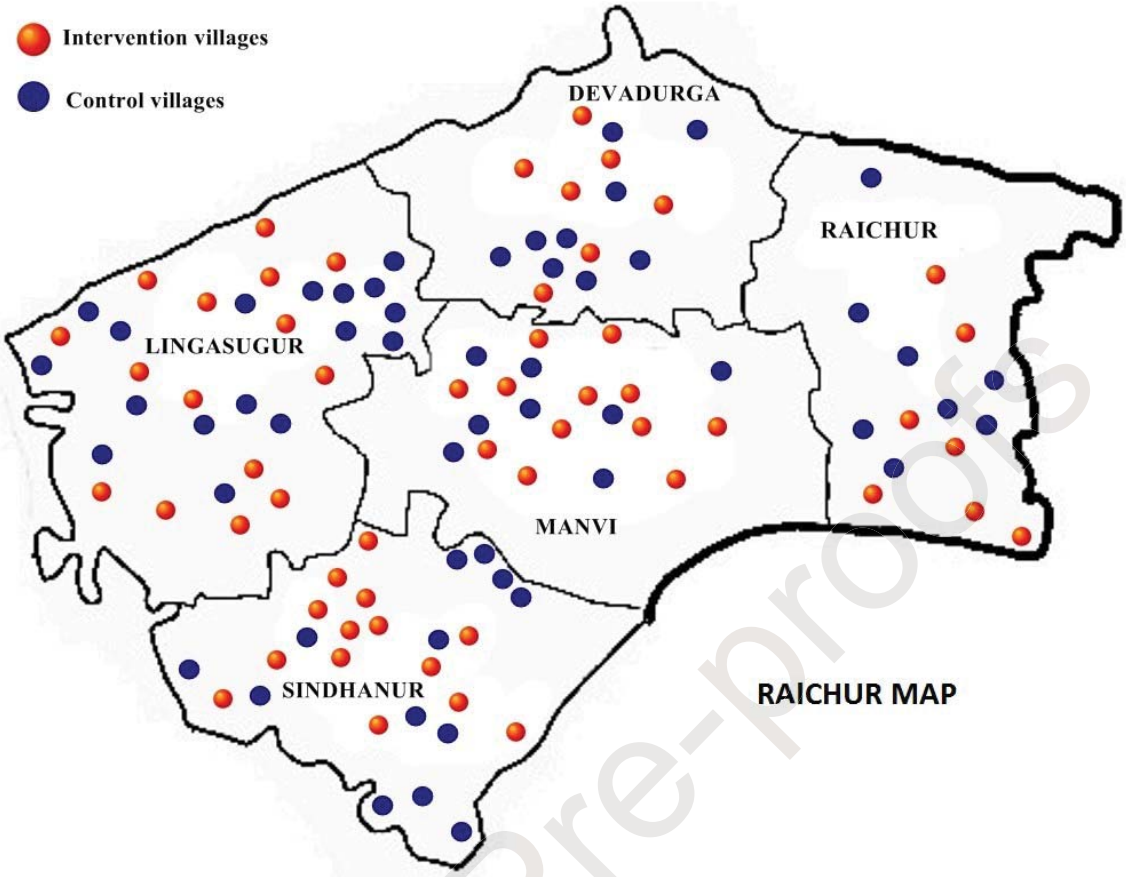
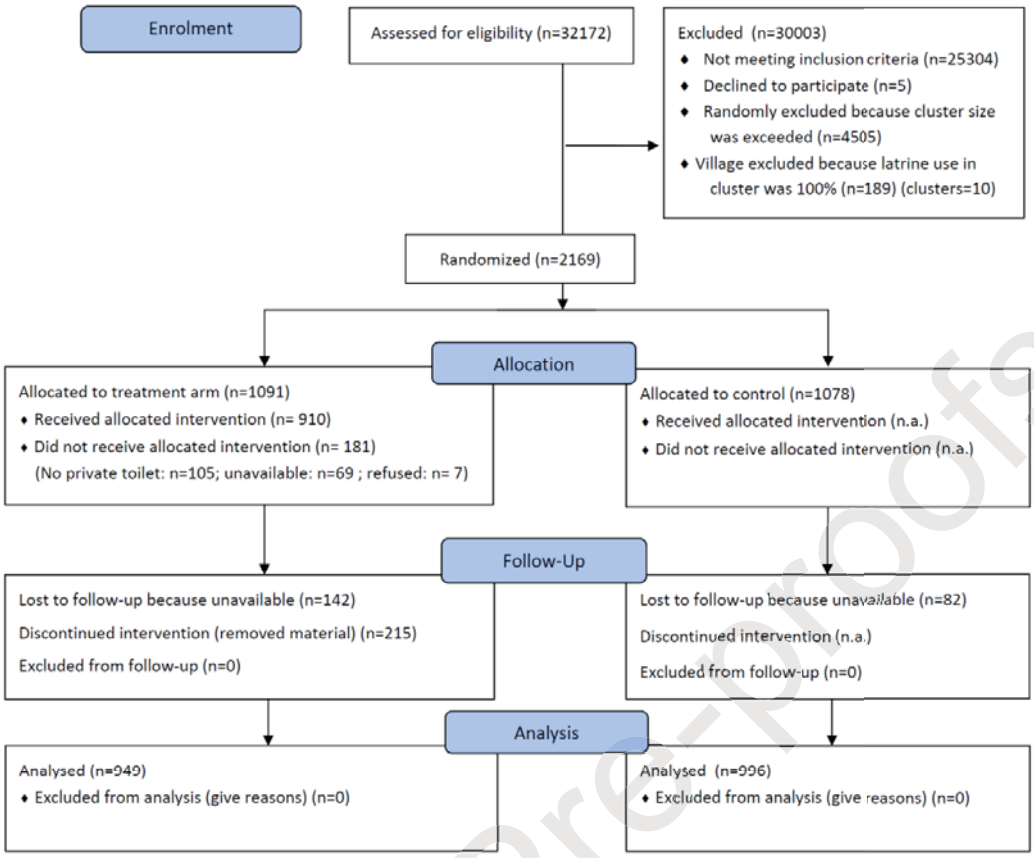
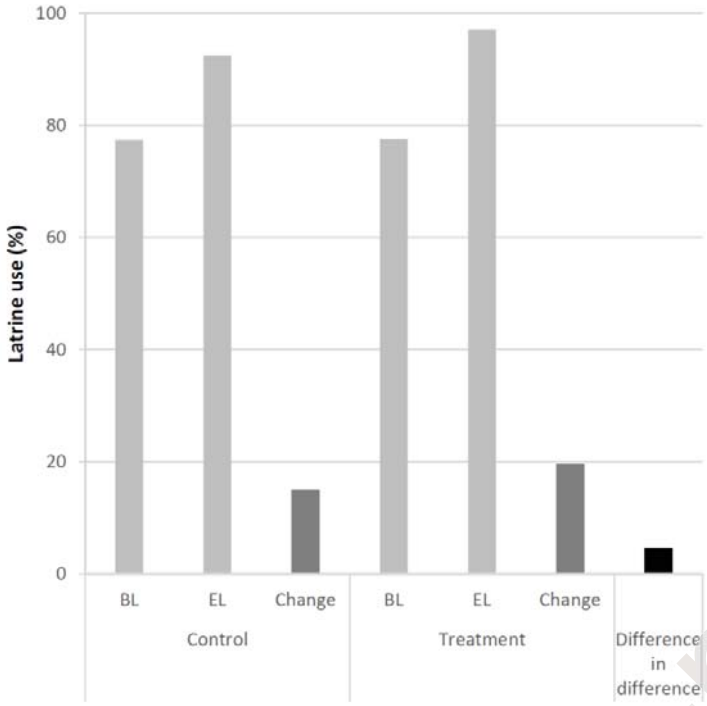






Strategy	Communication channel	Target individuals	Behaviour change technique (BCT)	Activity	Ranas factor targeted
1	Village meeting	Entire village	BCT 5 Inform about and assess costs and benefits BCT 8 Describe feelings about performing and about consequences of the behaviour	Costs of and negative feelings associated with OD and benefits of and positive feelings associated with LU are highlighted in an audio play.	Beliefs about costs and benefits, Feelings
			BCT 15 Provide instruction	Information on how latrine pits can be emptied are presented and distributed on a flyer.	How-to-do knowledge (maintenance)
			BCT 13 Provide a positive group identity	A video interview is screened, highlighting that OD conflicts with important values of the village, which has been recorded in a real ODF villages and with latrine users in the intervention village.	Personal importance
2	Household visit	All family members	BCT 10 Prompt public commitment	Family members commit to consistent latrine use through taking a family photo (see Strategy 3).	Others' behaviour
			BCT 34 Use memory aids and environmental prompts	Stickers are put on the tumblers normally used for anal cleansing. Another sticker is put where the tumblers are stored or refilled before OD.	Remembering
			BCT 30 Prompt coping with barriers / BCT 32 Prompt to resist social pressure	Participants are asked if they have experienced barriers to latrine use and ways how to overcome them are discussed.	Barrier planning
			BCT 19 Prompt behavioural practice / BCT 22 Use arguments to bolster self-efficacy	Participants are encouraged that they are able to use the latrine.	Confidence in performance

		Male family members	BCT 26 Prompt specific planning	Participants plan when exactly to use the toilet in specifying the activities of their morning/evening routine.	Action planning / Control
3	Phone	Male family members	BCT 34 Use memory aids and environmental prompts BCT 27 Prompt self-monitoring of behaviour	Thank the participants for committing to latrine use. Participant is asked on the phone if they used the latrine.	Remembering/ Action control
			BCT 19 Prompt behavioural practice / BCT 22 Use arguments to bolster self-efficacy	Participants are encouraged that they are able to use the latrine.	Confidence in performance
	Household visit	All family members	BCT 10 Prompt public commitment	The family photo (see Strategy 2) is put on the template and stuck on the wall in the entry or veranda of the house.	Others' behaviour

Is the latrine being used for some other purpose? *
Is the squatting pan clogged with leaves/dirt/other materials? *
Is there a water container (for washing after defecation) in or near (within 1 meter) the latrine?
Are there slippers outside or inside the latrine?
Is there electric light in the toilet?
Are there supplies to clean the latrine pan (i.e. toilet brush, cleaning fluid like Harpic)?
According to your (data collector's) judgment, does the latrine look like it is likely being used?

Note: * Items were reversely coded for computing the index.

	Control		Treatment		Mean Difference
	M	SD	M	SD	
Female respondent (%)	51.95	49.99	51.31	50.01	0.64
Age of respondent (years)	38.91	13.82	37.94	13.91	0.98
Household size (members)	5.01	2.39	4.89	2.42	0.12
Households which own a house (%)	98.84	10.71	99.10	9.47	-0.26
Households which own agricultural land (%)	80.80	39.41	79.02	40.74	1.79
Size of land owned (acres)	4.78	7.63	4.15	7.22	0.63
Households which have a ration card (%)	93.57	24.55	92.87	25.74	0.69
Highest level of education in the household (years)	9.71	4.77	9.75	4.79	-0.05
Households which belong to SC/ST/OBC (%)	79.56	40.35	81.33	38.99	-1.77
Latrine use (%)	77.40	36.51	77.54	36.26	-0.14
Latrine observation index	70.37	26.76	68.17	28.17	2.20

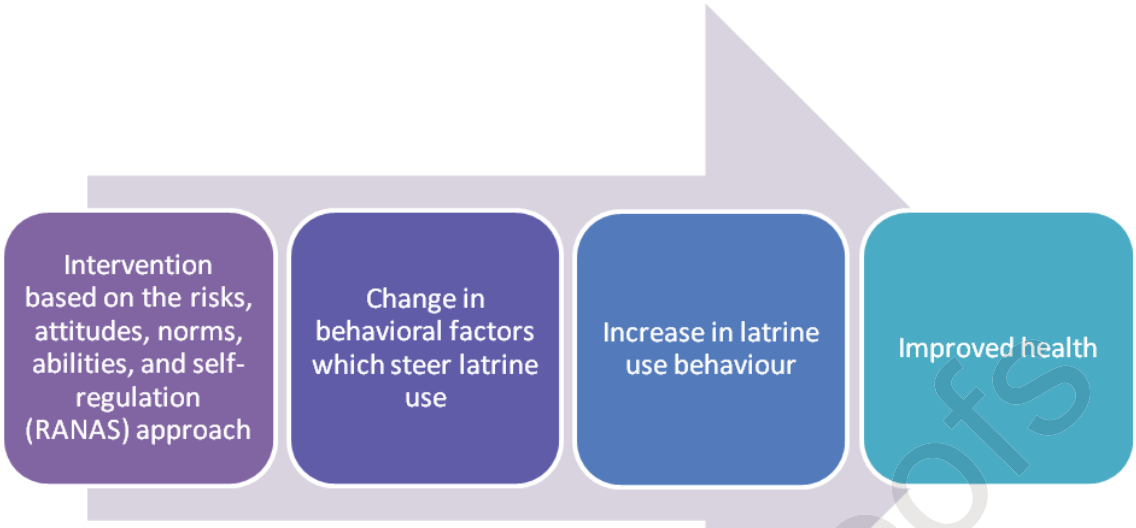
Note: N = 1954, SD = Standard Deviation.

Variable	Evaluation sample		Dropout		Mean difference
	M	SD	M	SD	
Female respondent (%)	51.62	49.99	50.89	50.10	0.73
Age of respondent (years)	38.41	13.87	35.89	14.55	2.53
Household size (members)	4.95	2.41	4.84	2.37	0.11
Households which own a house (%)	98.97	10.09	97.77	14.81	1.20
Households which own agricultural land (%)	79.89	40.09	81.70	38.76	-1.81
Size of land owned (acres)	4.46	7.43	4.14	6.98	0.31
Households which have a ration card (%)	93.21	25.16	93.75	24.26	-0.54
Highest level of education in the household (years)	9.73	4.78	9.45	4.84	0.28
Households which belong to SC/ST/OBC (%)	80.46	39.66	83.48	37.22	-3.02
Latrine use (%)	77.47	36.37	73.39	39.40	4.08
Latrine observation index	69.25	27.51	65.37	29.62	3.88

Note: N (Evaluation sample) = 1945. N (Dropout) = 224.

Activity Indicator of intervention participation	M	SD
Community meeting		
Participation by at least on HH member	72.8	44.5
Handout observed	63.6	48.2
Household visit		
Participation by at least one HH member	84.0	36.6
Commitment photo observed	74.1	43.8
Action plan observed	72.0	44.9
Sticker observed	73.1	44.4
At least one material observed	78.4	41.2
Phone call[$]		
Participation by at least one HH member	69.9	45.9

Note: N=949 in control arm. N = 996 in treatment arm. [$] Due to a programming error, sample N = 664 in control and N = 869 in treatment arm. All values represent percentages.



Highlights

- Existing latrine use promotion in India was not grounded in psychological theory
- The RANAS approach is a framework for tailoring interventions to target audiences
- The RANAS intervention increased latrine use in the Swachh Bharat Mission
- It can complement the ongoing campaign by targeting change-resistant individuals