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Impacts of low-cost interventions to improve latrine use and safe disposal of child faeces in rural Odisha, India

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Water sanitation and waste management

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Impacts of low-cost interventions to improve latrine use and safe disposal of child faeces in rural Odisha, India

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Summary

Globally, an estimated 892 million people – approximately 12 per cent of the global population – defecates in the open. Ending open defecation by 2030 is the aim of Sustainable Development Goal 6, Target 2, which importantly shifts the focus from just sanitation access (emphasised in the Millennium Development Goal era) to sanitation behaviour.

In India, where an estimated 60 per cent of those practising open defecation reside, the government has also shifted its focus to prioritise ending open defecation rather than increasing coverage alone. Research has demonstrated that access to sanitation enables but does not guarantee its use. Therefore, there remains a need to understand the barriers to latrine use amongst household members that own latrines, and to create and evaluate interventions to address them.

Emory University undertook formative research to understand specific barriers to latrine use in rural Odisha, India – including the validation of previously identified barriers to use – and to use their findings to design a theoretically informed intervention to increase latrine use and safe disposal of child faeces. The resultant multi-level intervention, called Sundara Grama, included community-level activities that were designed to reach latrine-owning households and non-latrine-owning households alike.

Community-level activities included:

- A music and humour-filled ***palla*** (a folk dance performance common in Odisha), which communicated messages about latrine use, health, child faeces disposal and the importance of overall village cleanliness;
- A **transect walk** that toured the village and marked piles of faeces with coloured powder along the way;
- A **community meeting** to discuss the state of the village and create a plan for ensuring its cleanliness;
- The **recognition of latrine-using households**, specifically those whose members all use the latrine all the time, with a banner hung in front of their house to indicate their latrine use behaviour has been confirmed and recognised by community members at the community meeting;
- **A village map painting** of all households, with special recognition of those using the latrines at all times and a description of the community action plan decided in the meeting.

Household-level activities included:

- A **targeted visit specifically for latrine owners**, reiterating messages from the other activities and eliciting commitment from household members to use the latrine to keep the village clean and beautiful;
- **Minor repairs** were carried out for latrines that were not functional, including those missing or broken doors were replaced.

Finally, a **mothers' group meeting** was created for mothers and caregivers of children under five years of age, regardless of their household latrine status, to provide action knowledge and hardware to enable the safe disposal of child faeces.

We conducted a cluster-randomised controlled trial to determine if the intervention had an impact on latrine use and safe child faeces disposal behaviour. We engaged 72 villages to evaluate the intervention, with 66 involved in the full trial (33 received the intervention, 33 served as controls) and 6 engaged in a simultaneous qualitative inquiry called the qualitative sub-study (3 received the intervention). In the 66 full-trial villages, a census was conducted from February to April 2018 to identify the latrine status of all households and determine latrine use behaviours of all members in latrine-owning households, including disposal of child faeces.

The *palla*, transect walk, community meetings, household recognitions and visits, and mothers' group activities were carried out from June to July 2018. Wall paintings were carried out in September 2018, and latrine repairs were undertaken from July to November 2018. Endline data collection took place from November 2018 to February 2019, again targeting all households in the trial villages to determine latrine ownership and use amongst appropriate households.

Intervention delivery was observed as part of a rigorous process evaluation in all 36 villages that received the intervention (33 from the cluster randomised trial, 3 from the qualitative sub-study) in order to understand if all the activities were carried out as designed and if they reached target participants.

Additional qualitative research was carried out in the three qualitative sub-study villages that received intervention activities to examine perceptions of the interventions. The three villages that did not receive intervention activities were assessed for potential spillover. Finally, questions about the intervention were asked during endline data collection in all 66 trial villages to assess awareness of and participation in activities.

Latrine use increased in both intervention and control communities. We found an increase in reported latrine use of 6.4 per cent (95% confidence interval 2.0–10.7%, $p = .004$) amongst individuals aged five and over in the intervention group at endline, after accounting for the increase in latrine use observed in the control group.

We also found an increase in reported safe child faeces disposal of 20.4 per cent (95% confidence interval 11.7–29.2%, $p < .001$) in the intervention group at endline, after accounting for the increase in safe disposal of child faeces observed in the control group. No difference was observed between intervention and control groups in the proportion of households that did not have a latrine at baseline and the proportion of households that had one at endline.

Overall, the intervention activities were well received, particularly the *palla*, which participants found entertaining and funny. With the exception of the mothers' group (which reached an estimated 96 per cent of latrine-owning households with children under five), reach for all other activities could have been improved. Poor recruitment, specifically of community members in hamlets or other parts of the village, may be a cause.

Women indicated barriers to attending activities, particularly the *palla* and community meeting, where men were in attendance, as well as the mothers' group if their families restricted them from leaving the house. Activities were delivered with fair to good fidelity overall, suggesting that improvements could result in greater increases in behaviour change.

Our result demonstrates that theory-informed interventions designed to change behaviour can be impactful. Latrine use behaviour is changing in the research area overall, but increased 6.3 per cent more in the intervention area. Importantly, our intervention also increased reported safe child faeces disposal by over 20 per cent. Safe faeces disposal practices were not widely practised in our research area before the intervention, primarily because their importance was not understood.

Additional investment in refining this and similar interventions is warranted to bring these efforts to scale, particularly as safe child faeces disposal has yet to be an investment and communication priority in government campaigns to date. The costs needed for safe management of child faeces disposal programmes, like ours, do not need to be extensive to enable change.

Moving forward, policymakers should leverage this and similar programmes to not only continue to influence behaviour change, but also to sustain changes already made. Increased investment to develop and evaluate evidence-based interventions specifically targeting behaviours is warranted. In turn, researchers need to engage target populations, apply theory to intervention design and conduct rigorous process evaluations to inform future adaptation and scale-up.

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Abbreviations and acronyms

BPL	Below poverty line
CI	Confidence interval
DID	Difference in differences
FGD	Focus group discussion
GEE	General estimating equation
IDI	In-depth interview
ITT	Intention-to-treat
OD	Open defecation
ODF	Open defecation free
RWI	Rural Welfare Institute
SBM	Swachh Bharat Mission
WASH	Water, sanitation and hygiene

1. Introduction

An estimated 892 million people – approximately 12 per cent of the global population – defecate in the open. Ending open defecation (OD) by 2030 is the aim of Sustainable Development Goal 6, Target 2, which importantly shifts the focus from just sanitation access (emphasised in the Millennium Development Goal era) to sanitation behaviour.

Research has demonstrated that access to sanitation enables but does not guarantee its use. In an ad hoc analysis as part of a systematic review, Garn and colleagues (2017) found that each 10 per cent increase in coverage led to a 5.8 per cent increase in use, revealing that OD is still practised by a considerable proportion of those who own latrines.

Therefore, concerted effort is needed to increase latrine use amongst latrine owners if the benefits of sanitation are to be realised (including impacts on diarrhoea, active trachoma, schistosomiasis, height-for-age, hookworm, ascaris lumbricoides, strongyloides stercoralis, intestinal protozoa infections, and well-being) (Freeman et al. 2016; Freeman et al. 2017; Sclar et al. 2018).

In India, where an estimated 60 per cent of those practising OD reside, the government has also shifted focus to prioritise ending OD over increasing coverage alone. Since the 1980s, the Indian government has implemented a series of missions and campaigns, focusing particular attention on rural parts of the country.

In 1986, the government launched the Central Rural Sanitation Programme, the first large-scale country-wide sanitation programme in India, through which rural households below the poverty line (BPL) were provided with subsidies for building toilets. In 1999, the Central Rural Sanitation Programme became the Total Sanitation Campaign, with new emphasis placed on community mobilisation and information, education and communication activities. Subsidies (now called 'incentives') were still provided exclusively to BPL households; however the amounts changed over the course of the 12-year campaign.

The Nirmal Gram Puraskar was set up in 2003, financially rewarding *gram panchayats* (village councils) that attained 100 per cent sanitation coverage. In 2012, the Total Sanitation Campaign became the Nirmal Bharat Abhiyam and extended the financial incentives, which were increased, to non-BPL households that fit certain criteria. In 2014, the Swachh Bharat Mission (SBM) was launched in both urban (SBM) and rural (SBM-Gramin) areas, with the goal of ending OD by Gandhi's 150th birthday on 20 October 2019. The SBM also includes information, education and communication activities and subsidies. As a result of these successive campaigns, many villages have experienced multiple government campaigns with different subsidy amounts.

The Indian government has been publicly tracking latrine construction efforts and the declaration of open defecation free (ODF) villages, districts and states on the SBM-Gramin dashboard (Department of Drinking Water and Sanitation 2019), which reports that 92,541,952 latrines have been built and 556,441 villages have been declared ODF since the start of the campaign.

The Research Institute for Compassionate Economics found a reduction in OD from 70% in 2014 to 40–50% in 2018 in the northern states of Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh amongst rural households surveyed at the start of SBM in 2014 and again in 2018 (Gupta et al. 2019). They reported that the proportion of latrine owners practising OD in 2014 and 2018 remained the same, suggesting that the reduction in OD was driven by latrine coverage increases alone.

Further, the data also suggest that not all coverage increases amounted to use, and that those who previously owned latrines and did not use them continue to defecate in the open. Therefore, there remains a need to understand barriers to latrine use amongst household members that own latrines, and to create and evaluate interventions to address them.

Several studies, by our team and others, have identified barriers to latrine adoption in rural India. Perhaps chief amongst these, especially in Hindu populations, are deep cultural attitudes of purity and pollution, where OD is viewed as healthier and purer than the use of household latrines (Coffey et al. 2015; Routray et al. 2015). Other barriers revolve around deficiencies in the functionality or acceptability of government-subsidised latrines, which often relate to issues of privacy and being able to practise cleansing rituals (poor design, incomplete construction, low wall height, no roof or door, lack of water, susceptibility to clogging, lack of light, bad odour) (Coffey et al. 2015; Routray et al. 2015; Banda et al. 2007; Barnard et al. 2013).

Some of the barriers involve practical issues (burden to clean, inconvenient location for men working in fields) or habits (time to socialise, exercise, accustomed to OD) that cause individuals to favour OD over the use of household latrines (Coffey et al. 2015; Routray et al. 2015; Banda et al. 2007; Barnard et al. 2013). Tied to purity is a fear of pit latrines filling up too quickly, requiring a household member to manually empty the pit – an act of ritual pollution (Coffey et al. 2015; Torondel 2015). Uncertainty about how quickly pits fill up and how to empty and dispose of pit contents safely is another barrier to their use.

Additionally, latrines are often perceived to be for women. Women are often the primary users of latrines in a household (Coffey et al. 2015; Routray et al. 2015; Barnard et al. 2013; Clasen et al. 2014). Privacy, modesty and safety of daughters-in-law are key motivating factors for men to build a household latrine (Coffey et al. 2015; Routray et al. 2015; O'Reilly and Louis 2014).

Women also have their own motivations for latrine use. They report having greater privacy, handling their menstruation more comfortably, saving time and not needing to wait for a family member to accompany them (Routray et al. 2015; Caruso et al. 2017; Hirve et al. 2015; Hulland et al. 2015; Sahoo et al. 2015). Conversely, latrines can reinforce women's isolation in the household, limit their mobility outside the home, and are not always perceived to be a better option than OD (Coffey et al. 2015; O'Reilly and Louis 2014; Caruso et al. 2017).

From January to April 2017, Emory University undertook formative research to understand specific barriers of latrine use in rural Odisha, India – including the validation of previously identified barriers to use – and to use findings to design a theoretically

informed, multi-level intervention to increase latrine use and safe disposal of child faeces. At present, according to the SBM-Gramin dashboard (Department of Drinking Water and Sanitation 2019), only 84 per cent of Odisha state has access to a household latrine – the second lowest latrine coverage in the country.

This report presents the results of a cluster-randomised controlled trial conducted to evaluate the intervention. In Section 2, we describe the intervention, including the proposed theory of change, and our strategy for evaluating intervention delivery. In Section 3, we detail the study design, including sample size, sample selection, tools, data collection procedures and ethics. Section 4 presents our research findings, including the process and impact evaluation, whilst Section 5 details the cost analysis. In Section 6, we present a discussion of findings, and finally conclusions are discussed in Section 7.

2. Intervention

2.1 Description

2.1.1 Setting

The formative research, intervention design, piloting and evaluation were carried out in the rural district of Puri in the state of Odisha, India.

At the time of intervention implementation, Odisha state had the lowest toilet coverage of any state (56.29%), just below Bihar (57.35%), and the fourth-lowest percentage of ODF villages (21.87%) (Department of Drinking Water and Sanitation 2019). The sanitation context for Puri district was better than for the overall state, with 36.8 per cent of households using an improved sanitation facility in rural Puri and 23 per cent overall in rural Odisha (IIPS and ICF 2017a).

According to the National Family Health Survey conducted in 2015–2016, the majority of people in Odisha live in rural areas (83%) and more than 46 per cent of the population are recognised by the government as living BPL (IIPS and ICF 2017b). The predominant religion is Hindu (95%) and 20 per cent of households belong to scheduled castes and 23 per cent to scheduled tribes (IIPS and ICF 2017b).

In Odisha state, 84% of rural households have electricity, 88% have an improved drinking water source, 23% have an improved sanitation facility and 11% use clean fuel for cooking. Of the rural children under five years of age in Odisha, 10% had diarrhoea in the two weeks preceding the 2015–2016 NFHS; of those, 69% received oral rehydration salts and 69% were taken to a health facility. In addition, 35% of rural children under five in Odisha are stunted. Amongst rural women in Odisha age 15–49, 65% are literate; 65% of females age six and over have ever attended school (IIPS and ICF 2017b).

The water, sanitation, electricity and cooking situation in rural Puri district is better than in the overall context of rural Odisha state: 94% of rural households have electricity; 94% have an improved drinking water source; 36.8% of households have an improved sanitation facility; and 14% use clean fuel for cooking (IIPS and ICF 2017a). Of the rural children under five years in rural Puri, 7% had diarrhoea in the two weeks preceding the 2015–2016 NFHS and 17% are stunted. Amongst rural women in Puri age 15–49, 83% are literate; 79% of females age six and over have ever attended school.

2.1.2 Intervention design

Formative research was carried out from January to April 2017 to inform the design and piloting of a theoretically informed intervention that aimed to increase latrine use (including the safe disposal of child faeces) amongst latrine-owning households at an average cost of US$20 per household – a policy-relevant stipulation required by the International Initiative for Impact Evaluation (3ie).

As part of this formative research, we carried out an intervention design process that was informed by the behaviour-centred design steps (Aunger and Curtis 2016), the intervention mapping approach (Bartholomew et al. 2011), causal analysis using problem trees (Starr and Fornoff 2016) and theory of change creation (Starr and Fornoff 2016; Aunger and Curtis 2016; De Silva et al. 2014).

We identified behavioural factors and subfactors that determine latrine use and safe disposal of faeces using an expanded version of the behaviour-centred design checklist from Aunger and Curtis (2016). This included relevant and distinct components of both the COM-B (capability, opportunity, motivation and behaviour) model of behaviour (Michie et al. 2011) and the RANAS (risks, attitudes, norms, abilities and self-regulation) model (Mosler 2012).

Through this process, we identified the following behavioural barriers as responsible for non-use of latrines for defecation or disposal: (1) non-functional latrines; (2) lack of practical knowledge regarding latrine use; (3) preference for OD; (4) latrine use not prioritised and/or valued; (5) unsuitable latrine design; and (6) inaccessible water.

Latrine design and water access were deemed beyond our ability to address, given the limitations of funding and time; thus, we focused on the remaining four barriers. We do acknowledge that some households or household members will not be able to use their latrines because of design and water issues, despite potentially being motivated by our intervention activities to use them.

For some, these barriers may be too great to overcome. Water is needed to flush the type of latrines available in Puri, and whilst Puri is not water-scarce, access water to can vary by village (variable water sources), household (variable proximity to sources) and individual (variable physical ability to get, carry and use water). Latrine design may also be quite variable. Based on our formative work, we know the common latrine design is challenging for people with disabilities and older village residents who cannot easily get inside the latrine and squat.

With regard to safe disposal of child faeces specifically, we determined that the primary barrier was a lack of awareness and action knowledge regarding safe practice. See Section 2.2 for a discussion of the theory of change.

2.1.3 Description of the intervention package

Based on the barriers identified in the formative research phase, we developed a multi-level intervention to address the primary barriers to latrine use (non-functional latrines, lack of practical knowledge regarding latrine use, preference for OD, latrine use not prioritised and/or valued) and safe disposal (lack of action knowledge).

The overall motto of the intervention was *moro swacha, sustha, sundara grama* (my clean, healthy, beautiful village). Recognising status as an important behavioural driver during the formative work, we intentionally focused on the reputation of the village, amongst other villages, as a driver. This motto was to be repeated across all activities, along with the name of the intervention, Sundara Grama, or 'Beautiful Village'.

The intervention activities were to be delivered at multiple levels, including the village level, the household level and at a subgroup level for all mothers or caregivers of children under five. Each intervention activity is briefly described below by level of delivery as designed and intended to be delivered.

Village-level activities

- *Pre-intervention community visits:* Community mobilisers from Rural Welfare Institute (RWI) were to make preliminary visits to each village to build rapport with key village stakeholders, foster support for the intervention, plan intervention logistics (e.g. location and date for activities) and learn about the social dynamics of each village before any intervention activities were to take place.
- *Palla performance:* A *palla* (traditional folk art performance) was to be the first activity to take place in each village. *Pallas* were performed by local troupes hired, trained and managed by RWI. Songs and skits aimed to engage village members around the health and non-health benefits (e.g. comfort, privacy) of latrine use, as well as increase action knowledge around the practices of latrine use, pit emptying and safe disposal of child faeces.
- *Coloured powder transect walk:* After the *palla* performance, ideally within the week, community mobilisers were to conduct a surprise transect walk in each village. These were intended to enable village members to recognise the amount of faecal contamination in their village due to OD, and therefore re-evaluate the condition of the environment and generate a sense of disgust and possibly shame. By starting first thing in the morning, the walk was designed to be carried out when all or most household members were still at home to enable participation by all. The use of bells and other noise makers were to be employed to draw attention to the activity and summon participants.

  All walks were to weave through the village streets and eventually end up at known defecation sites (which were to be previously identified by community mobilisers during the pre-intervention community visits). At the first sight of human faeces, community mobilisers were to use brightly coloured powder, traditionally used for the Hindu spring festival known as Holi, to mark piles of faeces. Community mobilisers were then to distribute bags of powder to participants and encourage them to mark all piles of faeces seen during the walk. After the faeces-marking activity, the walk ended at a water source to have a reflection discussion amongst participants as well as a handwashing demonstration, for which participants were provided soap.
- *Community meetings:* Community meetings (one for women and one for men) were to be facilitated by community mobilisers to help participants decide upon a set of action steps to achieve the goal of a *swacha, sustha, sundara grama* (clean, healthy, beautiful village). Community members were to be encouraged to identify actions they felt could achieve this goal (e.g. cleaning the village pond or roads). If

it was not brought up as part of the action-planning process, community mobilisers were to suggest including latrine use by all members of the household at all times.

During the meeting, those in attendance were also to be asked to identify 'positive deviant' households where all the members always used their latrine for defecation at all times. This information would later be used to formally recognise these households and make them known to other community members for their behaviour.

- *Positive deviant household recognition:* Households identified as positive deviants by participants in the community meetings were to be provided with a banner to display (at their discretion) in front of their house to publicly recognise that all members of their household use the latrine all the time – as confirmed by members of the village – thus praising their contribution to achieving a 'clean, healthy, beautiful village'.
- *Village wall painting:* As a final activity, community mobilisers were to hand-draw maps of each village, depicting major features like roads and temples, as well as all households. This draft map was to be copied by local artisans in the form of a mural painted in a location agreed upon by participants in the community meeting. The mural was meant to distinctly identify positive deviant households in order to serve as a reminder to all village households and to motivate all household members to use their latrines all the time.

  To the side of the map, the wall painting also displayed the action steps decided upon in the community meeting in order to remind the community of the agreed actions to achieve the goal of a 'clean, healthy, beautiful village'. The mural's display of the action steps also enabled members not present at the meeting to be aware of what was discussed and decided upon.

Subgroup-level activity

- *Mothers' meetings:* Community mobilisers were to hold 'mothers' meetings', which were open to all mothers, as well as other caregivers, of children under five. Their aim was to provide participants with information about the health risks of unsafe child faeces management, and the necessary action knowledge and hardware (i.e. plastic scoops and potties) to enable the practice of safe child faeces disposal.

  Participants were to be provided with information on how to use the hardware provided, including how to properly dispose of faeces and how to clean and store the hardware. As meetings were open to all mothers and caregivers of children under five in the village, regardless of latrine ownership, the community mobilisers were to emphasise that those who owned a latrine should dispose of faeces and any water used to wash hardware or cloths into the latrine, whilst those without latrines should bury faeces and contaminated washing water.

Household-level activities

- *Household visits:* A community mobiliser was to make individualised visits to all latrine-owning households to reflect with members on the intervention activities to date and reiterate key messages. Messages would be repetitive for some household members and new to others who had not been able to attend or hear about any of the intervention activities previously carried out.

Visits were not forced; household members could refuse the visit or aspects of the visit. Community mobilisers were also to lead household members in a voluntary pledge to work towards the village goal of achieving a 'clean, healthy, beautiful village', which was to include latrine use by all members of the household at all times. At the end of the visit, each household was to be given a poster, which they could refuse, with key messages about latrine use to serve as a reminder of their commitment.

- *Latrine assessment and repairs:* Acknowledging that a key barrier to latrine use is lacking access to a functional latrine, India-based Emory team members were to assess latrines with representatives from local contracting partners, who repair latrines, to jointly identify repairs needed. Latrine-owning households that were in need of minor repairs and deemed eligible for assistance were then to have their latrines fixed.

2.1.4 Key partners involved in the delivery of the intervention

RWI, a grassroots NGO based in Nimapara District and led by Director Prabhakar Nanda, was engaged as the implementing partner for delivery of the Sundara Grama intervention. The RWI implementing team consisted of 4 supervisors (1 woman and 3 men) and 16 community mobilisers (12 women and 4 men). The majority of community mobilisers were in their twenties and had completed +3 schooling (bachelor's degree). Some had previous work experience in social services and community development, whilst for others this was their first official job position.

The RWI mobiliser team was trained by Emory team members on all of the intervention activities over the course of 12 training days, which included both in-house and field practice. The RWI team was responsible for making initial visits to the community (to build rapport with community stakeholders and organise activity logistics) and leading the following activities: transect walks, community meetings, positive deviant identification and recognition, mothers' group meetings, household visits and mapping households for the wall paintings. The RWI team split into four sub-teams, each comprising one supervisor and four mobilisers. Each sub-team implemented all of the intervention activities across the 8 to 10 villages to which they were assigned.

Additional partners were engaged to complete the *palla* performances, wall paintings and latrine repairs. Performances were conducted by two *palla* groups with five or six members each. Community wall paintings were completed by two local artisan groups with four or five members each.

Latrine repairs were completed by two local contracting groups, Gopabandhu Seva Parisad (assigned 20 villages in Pipili and Delang blocks) and Jageswari Jubak Sangha (assigned 16 villages in Pipili and Nimapara blocks). An assessor from each group was paid to go to each selected household and complete a full assessment of the latrine. About 815 households were selected for latrine assessment across the 36 intervention villages (33 main trial and 3 sub-study qualitative).

The two assessors completed their work over the course of three months. The two contracting groups completed latrine repairs in 457 households across the 36 intervention villages. Households that planned to destroy their latrine, required an

entirely new superstructure or pit, or used their latrine as storage and did not remove the storage items during the assessment were not eligible for repairs. The types of repairs included about 233 slab repairs, 153 I-pipe repairs, 43 pan repairs, 363 door repairs, 130 pit repairs and 117 floor repairs. The average cost of latrine repairs per household, including material and labour, was Rs922.47 (equivalent to 13.00USD on 1 September 2018).

Control villages were not provided with intervention activities after endline.

2.1.5 Changes to the intervention during the course of the study

Minor changes were made to intervention activities (e.g. slight revisions to activity scripts and facilitator guides) based on pilots in villages not included in the trial or qualitative sub-study prior to delivering activities to intervention communities engaged in the trial.

A minor change that could have resulted in a negative impact if not addressed was the colour of the powder used during the transect walk activity. In one pilot village, red powder was used and participants informed the RWI mobilisers that it was not an appropriate colour because of its connection to different religious practices. RWI and Emory team members discussed this lesson learned and decided that neither red nor orange (also noted as a religious or sacred colour) would be used during the transect walk. To ensure a non-religious colour was used, the Emory team added a question to the transect walk process evaluation survey about the colour of the powder.

During intervention delivery, the household visit activity was revised due to resource constraints. Specifically, it was originally designed to be a 45-minute visit that included 4 key activities: (1) reflection on village goal and action steps; (2) demonstration of how faeces spread (using a glass of water, mustard paste to represent faeces, and a piece of thread to represent a fly's leg); (3) discussion of individuals' latrine use with barrier planning; and (4) household commitment and distribution of a reminder poster.

These activities incorporated a variety of behaviour change techniques. However, RWI staff could only be employed for a set amount of time in order to meet the US$20 per household cost limit to the intervention. Since the other Sundara Grama activities took longer than expected to complete, there was not enough time for RWI staff to complete a 45-minute visit for every household with a latrine.

In order to resolve this issue, we cut out activities 2 and 3 so that the visit only took about 10 minutes to complete and only included a quick reflection and then the household commitment with a reminder poster. Unfortunately, this meant that some important behaviour change techniques, such as barrier planning, had to be cut from the visit. However, with this modification, the household visit activity was able to be completed by RWI staff across all intervention villages.

This revision to the household visit was made before the household visit activity commenced, and RWI staff received a 'refresher training' on the activity to ensure that they were properly trained on the changes. As such, all intervention households should have received the same version of the household visit activity.

Any deviations in delivery of the intervention from the original implementation plan will be reported in Section 4.1 (intervention implementation fidelity).

2.1.6 Programme participants

The intervention targeted all members of households that owned at least one latrine across all trial villages.

As a separate aspect of the study known as the sub-study qualitative, six additional villages were engaged in qualitative activities – three received the intervention and three were control villages. They were in the same blocks within Puri as the other villages, and are likely to be similar demographically, although they were not involved in the baseline census that would enable us to report specific characteristics. From a pre-enrolment village mapping phase, we know that these six sub-study villages ranged in size from 90 to 174 households (mean: 130 households) and had a latrine coverage of 49.43 to 79.25 per cent (mean: 60.33% latrine coverage).

2.2 Theory of change

The theory of change outlines all identified barriers, proposed intervention activities and environmental and psychosocial determinants targeted to achieve consistent latrine use. It also lists the assumptions and behaviour change strategies employed (Figure 1). Overall, our assumption was that latrine use would increase by: (1) improving the **physical environment**, specifically by increasing access to functional latrines; (2) improving the **social environment** (norms) of latrine use and encouraging rejection of OD; and (3) targeting key **'brain' or psycho-social determinants** like personal-level motivators (namely status, justice, comfort, disgust and nurture),the ability to practise latrine use and safe faeces disposal, risk perceptions associated with OD and 'self-regulation', or ability to sustain these behaviours.

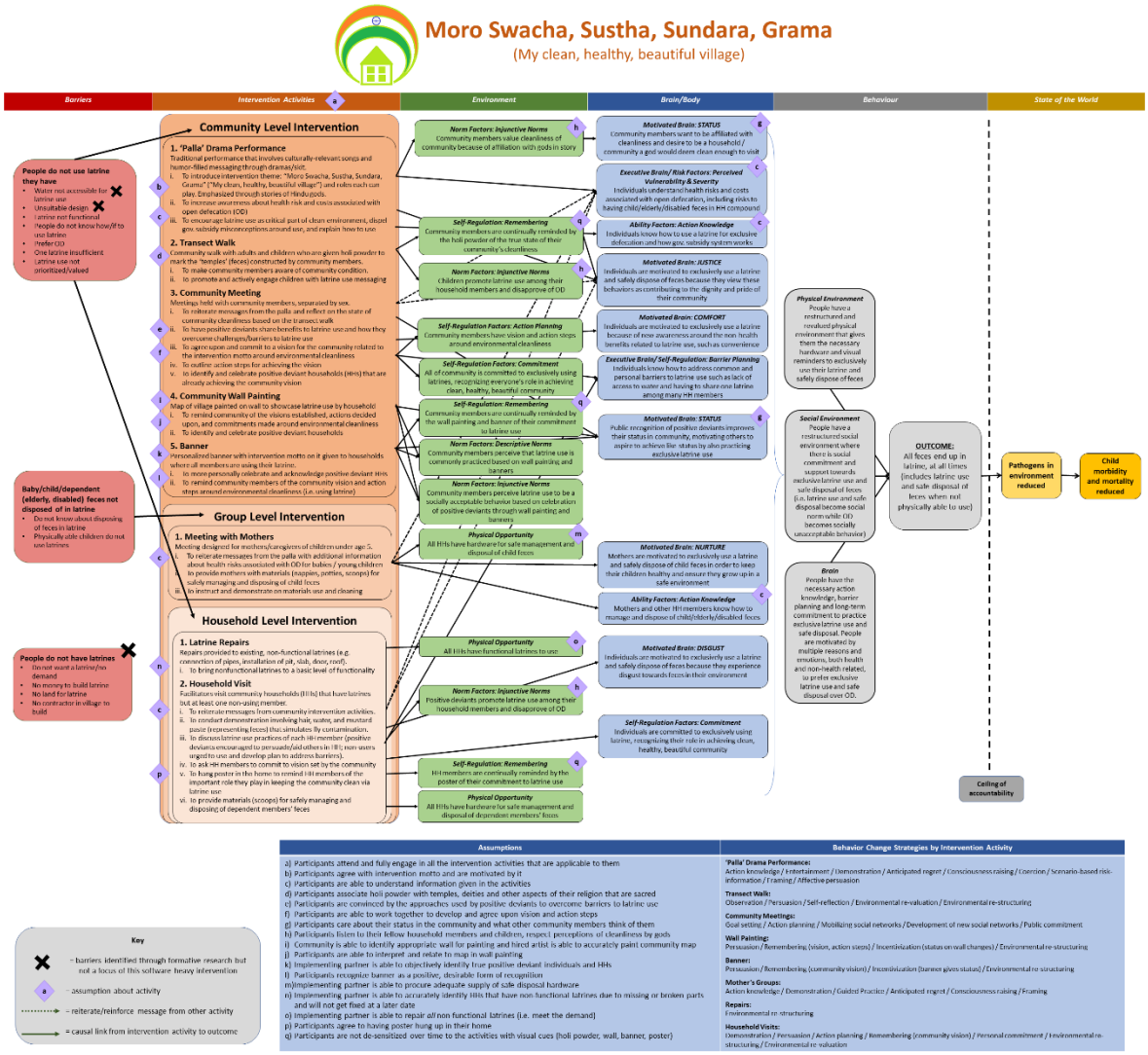
The components in the theory of change are explained below **by barrier**, providing details of how the intervention activities addressed the identified barriers, and discussing the behavioural techniques utilised. The final paragraph also describes key **motivators** for latrine use identified through the formative research.

2.2.1 Behavioural barriers and intervention activities

To inform our intervention design process and the selection of intervention activities during the formative research phase (January to April 2017), we held a meeting in a rural village with community members and a partner organisation, Bhabagrahi Kala Niketan. The purpose of this meeting was to work with community members to build a problem tree to visually identify all possible barriers to latrine use and safe disposal of faeces, and use this to identify possible solutions to address these barriers (by creating a solution tree) (Snowdon et al. 2008).

The problem and solution trees helped us to identify the behavioural factors that we needed to target through our intervention activities. Once the behavioural factors were identified, we used the intervention mapping approach (Bartholomew et al. 2011) to identify various behaviour change techniques that could influence the specific behavioural factors identified (Michie et al. 2011; Bartholomew et al. 2011; Mosler 2012). For example, we learned that mothers and caregivers of young children did not know about safe faeces disposal practices or how to perform these behaviours. The behavioural factors we needed to target for these barriers included psychological capability and ability (Michie et al. 2011; Mosler 2012).

Figure 1: Theory of change



Note: HH = household.

Behaviour change techniques recommended for targeting these factors included providing action knowledge (Mosler 2012) and modelling, or providing an example for people to imitate (Bartholomew et al. 2011). We decided that the action knowledge should be communicated to all community members, and therefore included it in a community-wide event. However that modelling would be best executed in a more intimate setting with mothers and/or caregivers in order to enable discussion and even practice. We therefore created activities around these behavioural strategies.

Below, the barriers to latrine use and safe disposal of faeces are noted, along with further information about the behavioural factors and strategies utilised in the activities.

Non-functional latrine: Household latrine repairs create a physical environment that enables latrine use.

Lack of practical knowledge regarding latrine use: Palla performances use demonstration and action knowledge strategies to teach community members how to use a latrine.

Preference for OD: Palla performances use various strategies, like scenario-based risk-information communication, so that individuals understand the health risks and costs associated with OD and unsafe disposal. *Pallas* also counter commonly cited benefits of OD with benefits of latrine use as a form of affective persuasion and a way to influence the cost-benefit perception around latrine use. Transect walks use environmental revaluation and self-reflection to generate disapproval of OD and awareness that one's environment is dirty and requires change.

Latrine use not prioritised and/or valued: Palla performances, community meetings, wall paintings and banners use a mix of affective persuasion, mobilisation of social networks, incentivisation and environmental restructuring to establish a status motive and injunctive norm around latrine use. The community meeting in particular utilises goal setting and action planning to help establish a collectively generated prioritisation of latrine use. Remembering, pledging and environmental restructuring are also used through the community meeting, wall painting and household visits to create a descriptive norm and social commitment towards latrine use.

Do not know about safe disposal: Mothers' meetings provide action knowledge on the different ways to safely dispose of child faeces, depending on the age of the child and their defecation habits (i.e. infants, toddlers or young children), demonstrate these safe disposal practices, provide guided practice, and create an enabling environment by providing different types of safe disposal hardware (i.e. potties and scoops).

Cleanliness, beauty and status as motivators: Importantly, all of the intervention activities reiterated and emphasised the intervention motto of a 'clean, healthy, beautiful village'. This motto was developed based on formative research findings that found cleanliness, beauty and status in particular to be important motives for behaviour in the study context. As such, the motto acts as an affective persuasion strategy that is consistently employed throughout the intervention.

The motto aims to shift community members' views on latrine use from seeing it as a behaviour that is not prioritised or valued to a behaviour that has clear influential motivations. The motto is especially highlighted through targeted discussion in the community meeting activity, and the motivators (cleanliness, beauty and status) specifically informed one of the central skits in the *palla* about the goddess Laxmi.

2.3 Intervention monitoring plan

2.3.1 Process evaluation indicators

We conducted a mixed-methods process evaluation to monitor delivery of all intervention activities, informed by the guidance of Saunders and colleagues (2005). Specifically, we aimed to understand intervention fidelity, dose, reach, recruitment, satisfaction and context. Each of these components is defined in Table 1 below.

We created a process evaluation manual that outlined how each intervention activity would be assessed along the key components noted. Specifically, for each activity we created a table that noted each process evaluation component, the relevant process evaluation questions that would address that component, the data sources and tools needed to answer the questions identified, when data collection would need to take place to gather accurate information, and what the data analysis plan would be.

Table 1: Process evaluation components to be evaluated as part of Sundara Grama delivery

Component	Purpose
Reach (participation rate)	The extent to which the intervention reaches the intended population
Fidelity	The extent to which the programme is implemented as planned (e.g. in a manner consistent with its design)
Dose delivered (completeness)	The extent to which programme components are delivered
Recruitment	Procedures used to recruit and engage participants
Satisfaction	The extent to which the programme is received by the target group, including satisfaction and enjoyment of the intervention or programme activities
Context	Aspects of the environment that may influence intervention implementation or outcomes

Source: Definitions from Saunders and colleagues (2005).

2.3.2 Process evaluation data collection tools and data sources

The process evaluation data collection tools were both qualitative and quantitative, and are summarised in Table 2 along with information on their intended purpose. The majority of the process evaluation data were collected during the intervention activities. Qualitative process evaluation data were collected after intervention delivery in sub-study villages and post-endline in full-trial villages, and some process evaluation questions were included in the endline survey.

Process evaluation data collected at the time intervention activities took place assessed reach, fidelity and dose. Qualitative activities, specifically in-depth interviews (IDIs) and focus group discussions (FGDs), were used to assess the recruitment, satisfaction and context components. These tools are listed in Table 2 and described in Section 3.4.2 (data description).

Process evaluation questions asked as part of the endline survey assessed various components depending on the activity, including reach, dose and satisfaction. Specifically, all households regardless of latrine or intervention status were asked about awareness and attendance at intervention activities. For intervention communities, this enables further understanding of intervention reach. In control communities, questions about the intervention enable understanding of spillover. See Section 3.4.2 (data description) for more information on Section I of the endline tool.

2.3.3 Analysis of process evaluation data

Assessment of intervention reach

Intervention reach was assessed during intervention delivery and at endline.

For the *palla*, transect walk and community meeting, the Emory process evaluation team members used a tally counter device to count the total number of village members in attendance at a specific point during the activity (*palla* = number of audience members at

30 minutes into the performance; transect walk = number of individuals participating in the walk upon reaching the OD sites; community meeting = number of individuals participating in the meeting during activity 3 out of 7).

The process evaluation team members tallied the total attendees, as well as subgroups, by sex and age (total adult men, total adult women, total boys under 18 years and total girls under 18 years). For the mothers' group meeting, community mobilisers filled out a roster sheet of participants who attended. Using village data collected at baseline, we estimated the approximate proportion of target attendees in attendance at each of these activities.

For the *palla* and transect walk, we determined the proportion of the whole village in attendance; for the community meetings, we assessed the number of adults (18 years and over) in attendance; and for the mothers' group meeting, we assessed the number of caregivers from households with children under five in attendance. Within each activity, reach scores were determined for each village. These range from 1 to 10; a score of 0 equates to ~1–10% participation, a 1 equates to 11–20% participation, and so on.

For latrine repairs, we assessed reach during the endline survey. Respondents in all households that were supposed to have latrine repairs (as determined by our assessment in July to September 2019) were asked if they received them.

Table 2: Process evaluation tools for assessing the Sundara Grama intervention

Tool name	Purpose	Data collection logistics
Palla activity checklist	<u>*To assess:*</u> *Reach:* To record estimates of the number of participants (by sex and age group) in attendance at each performance *Fidelity:* To determine if the *palla* was delivered according to design *Dose:* To determine if all intended skits and messages were delivered	<u>Target:</u> All *palla* performances <u>Timing:</u> During *palla* performance <u>Administration:</u> Emory
Transect walk activity checklist	<u>*To assess:*</u> *Reach:* To record estimates of the number of participants (by sex and age group) in attendance during the transect walk *Fidelity:* To determine if the transect walk was delivered according to design *Dose:* To determine if each transect walk component, such as marking of faeces and specific messages, was delivered	<u>Target:</u> All transect walks <u>Timing:</u> During transect walk <u>Administration:</u> Emory
Community meeting activity checklist	<u>*To assess:*</u> *Reach:* To record estimates of the number of participants (by sex and age group) in attendance during the community meeting *Fidelity:* To determine if the community meeting was delivered according to design *Dose:* To determine if each community meeting component, such as creation of action steps and group commitment, was delivered	<u>Target:</u> All community meetings <u>Timing:</u> During community meeting <u>Administration:</u> Emory
Mothers' group activity checklist	<u>*To assess:*</u> *Reach:* To record estimates of the number of participants (by sex and age) in attendance during the mothers' group *Fidelity:* To determine if mothers' group was delivered as designed *Dose:* To determine if each mothers' group component, such as demonstrations	<u>Target:</u> All mothers' group meetings <u>Timing:</u> During mothers' group meeting <u>Administration:</u> Emory

Tool name	Purpose	Data collection logistics
	and hardware distribution, was delivered	
Household visit logsheet	*To assess:* *Reach:* To record the number of participants (by sex) in attendance during the household visit *Fidelity:* To determine if the household visit was delivered according to design *Dose:* To determine if each household visit component, such as the personal pledge and distribution of the poster, was delivered	Target: All household visits Timing: During household visit Administration: Community mobiliser from RWI conducted visit; Emory staff did oversight to make sure visits occurred, sheets were completed
Community wall painting logsheet	*To assess:* *Fidelity:* To determine if the community wall paintings were created as planned	Target: All wall paintings Timing: Once community wall painting complete Administration: Emory
Community members' perceptions of intervention activities (FGD)	*To assess:* *Recruitment:* To determine if community members had challenges and/or issues in attending activities *Satisfaction:* To assess perceptions of intervention activities (e.g. likes, dislikes) *Context:* To understand contextual factors that may have had an impact on delivery, attendance, participant perceptions of intervention	Target: Community members in sub-study villages Timing: Once community-level intervention activities complete Administration: Emory
Mother/caregiver perceptions of child faeces disposal messages and directed activities (mothers' group meeting) (IDI)	*To assess:* *Recruitment:* To determine if mothers and caregivers had challenges and/or issues attending activities *Satisfaction:* To assess perceptions of mothers' group activity (e.g. likes, dislikes) *Context:* To understand contextual factors that may have had an impact on delivery, attendance, participant perceptions of the mothers' group activity	Target: Mothers of children under age 5 in sub-study villages who attended the mothers' group meeting Timing: Once mothers' group activities complete Administration: Emory
Community mobiliser activity feedback – IDI	*To assess:* Community mobilisers' perceptions of the different intervention activities and	Target: 4 community mobilisers per activity

Tool name	Purpose	Data collection logistics
guides (one per activity)	experience of implementation	Timing: Once majority of focal activities complete Administration: Emory
Community mobiliser implementation feedback (FGD guide)	*To assess:* Community mobilisers' experiences of implementation	Target: 5 to 8 community mobilisers in 3 FGDs Timing: Once majority of focal activities complete Administration: Emory
Community members' perceptions of intervention activities (post-endline) (FGD)	*To assess:* *Recruitment:* To determine if community members had challenges and/or issues in attending activities *Satisfaction:* To assess perceptions of intervention activities (e.g. likes, dislikes) *Context:* To understand contextual factors that may have had an impact on delivery, attendance, participant perceptions of intervention	Target: Men and women (separate discussions) in trial intervention villages Timing: Post-endline Administration: Emory
Community members' perceptions of intervention activities (post-endline) (IDIs)	*To assess:* *Recruitment:* To determine if community members had challenges and/or issues in attending activities *Satisfaction:* To assess perceptions of intervention activities (e.g. likes, dislikes) *Context:* To understand contextual factors that may have had an impact on delivery, attendance, participant perceptions of intervention	Target: Men and women in trial intervention villages who did and did not exhibit change in latrine use Timing: Post-endline Administration: Emory
Mother and caregiver perceptions of child faeces disposal messages and directed activities (mothers' group meeting) (IDIs)	*To assess:* *Recruitment:* To determine if mothers and caregivers had challenges and/or issues in attending activities *Satisfaction:* To assess perceptions of mothers' group activities (e.g. likes, dislikes) *Context:* To understand contextual factors that may have had an impact on delivery, attendance, participant perceptions of the mothers' group activity	Target: Mothers/caregivers of children under age 5 in trial intervention villages who attended the mothers' group meeting who did and did not exhibit change in child faeces disposal behaviour Timing: Post-endline Administration: Emory

At endline, each household, regardless of latrine ownership, was asked if they recalled or had any member attend the various community-level activities (*palla*, transect walk, community meeting), or had seen the wall painting. All households with children under five, regardless of latrine use status, were asked if a member from their household had attended the mothers' group meeting. All households with latrines were asked if a community mobiliser had visited their household.

Assessment of intervention fidelity and dose
We created a combined 'fidelity/dose' score for each of the community-level activities (*palla*, transect walk, community meeting) and the mothers' group from relevant indicators in the activity-specific tools. Each activity has a maximum possible score, which is based on the number of components that the activity should include in order to have been delivered with fidelity and to be considered complete (dose). Scoring criteria for each of the activities are outlined in Online appendixes B, C, D and E.

Common fidelity components assessed across the various activities include: attendance by a key stakeholder, length of activity, appropriate pre-activity preparations, and delivery of activity components in the correct order. For dose, each activity had key 'events' that needed to take place for the activity to be considered 'complete'. For example, *pallas* included various songs, skits and stories, as well as opening and closing remarks. Each event within the activity was assessed with at least one, and sometimes several, questions by the observer to indicate if each event within the activity was carried out completely as planned.

We determined fidelity/dose of the household visit activity by assessing whether or not all three components of the activity were completed by the community mobiliser, namely: reflection of household practices, commitment and poster hanging.

We determined fidelity/dose of the wall paintings by reviewing photos of each completed painting to determine if all three key components were included, specifically: mapping of the entire village with houses, clear identification of positive deviant households on the map, and notation of the specific action steps determined in the village's community meeting.

For latrine repairs, we assessed dose during the endline survey. We asked respondents in all households that were supposed to get latrine repairs and who indicated that they got repairs, what repairs they received.

Assessment of intervention recruitment, satisfaction and context
We translated qualitative data, which were collected after endline and within the sub-study villages, as well as through notes written by the research team when they observed intervention delivery or recorded community members' perceptions when sharing trial findings back to intervention villages. Data were thematically analysed to generate a preliminary understanding of recruitment, satisfaction and context elements across activities.

For latrine repairs, we assessed satisfaction during the endline survey. We asked respondents in all households that were supposed to get latrine repairs and who indicated that they got repairs, how satisfied they were with the repairs they received.

2.3.4 Measures taken to ensure data quality

We anticipated that observation of the activities could influence delivery by the community mobilisers, as well as reception of the activities by community members. Thus, we elected to collect monitoring data *for all activities.* In addition to ensuring that the monitoring exercise had a uniform influence across intervention villages, the detailed data collected enabled identification of systematic issues across activities, villages and community mobiliser teams.

All members of the process evaluation team were trained and had the opportunity to pilot the tools and practice data collection in the villages where the intervention was piloted. During the piloting, team members reported challenges using mobile phones for data collection. As such, all tools were converted to paper to enable the team members to easily move through the tool and take notes. This was particularly important if activity components were delivered out of order or an unforeseen event occurred that needed to be captured (e.g. interruption, weather or the need to move locations).

3. Evaluation questions, design, methods, sampling and data collection

3.1 Primary and secondary evaluation questions

The objective of our study is to evaluate a multi-level, theoretically informed intervention designed to increase latrine use for defecation amongst all members of households that currently own a latrine. Our primary outcome for the study is latrine use. Secondary outcomes are latrine coverage and latrine use determinants.

The main evaluation questions to be tested and associated hypotheses are listed below.

Main research question: Is latrine use amongst people who own a latrine in communities that received the intervention significantly different at endline than amongst people who own a latrine in communities that did not receive the intervention?

- Hypothesis 1 (H1): Latrine use amongst people who own a latrine in communities that received the intervention will be significantly higher at endline than amongst latrine-owning households in control communities.

Secondary research question 1: Is latrine construction by endline significantly different for people who do not own a latrine in communities that received the intervention compared to those who do not own a latrine in communities that did not receive the intervention?

- Hypothesis 2 (H2): Latrine construction amongst non-latrine owners in communities that received the intervention will be significantly higher by endline than amongst non-latrine owners in control communities.

Secondary research question 2: Are behavioural determinant scores (i.e. scores for social norms, abilities, physical opportunity, risk perception, motivation and self-regulation) at endline amongst owners of latrines in intervention villages significantly different from those amongst owners of latrines in control villages?

- Hypothesis 3 (H3): Latrine use behavioural determinant scores amongst latrine owners in intervention villages will be significantly higher at endline than amongst latrine owners in control villages.

Secondary research question 3: Are behavioural determinant scores (i.e. scores for social norms, abilities, physical opportunity, risk perception, motivation and self-regulation) associated with latrine use?

- Hypothesis 4 (H4): High latrine use behavioural determinant scores are significantly associated with latrine use.

3.2 Evaluation design and methods

3.2.1 Identification strategy

We conducted a cluster-randomised controlled trial in rural Puri district, Odisha, India to determine if those who own latrines in villages that received a multi-level behaviour change intervention used their latrines significantly more at endline than those in control villages. A cluster-randomised design was selected because the intervention was to be delivered at the village level.

To assess immediate perceptions of the intervention and potential spillover, qualitative research was conducted in six sub-study villages (three of which had received the intervention and three of which were control) within one month of intervention delivery. Additional qualitative research was conducted in four of the main trial intervention villages within weeks of the endline data collection completion.

We interviewed a small number of individuals who according to endline data collection started using the latrine, as well as a small number of individuals who continued to not use the latrine, in order to understand what motivated change or stasis in their behaviours. Similarly, for the same purpose, we interviewed a small number of individuals who according to endline data collection started disposing of child faeces safely by endline compared to baseline, and a small number of individuals who continued not to dispose of child faeces safely.

Figure 2 shows a flow diagram of the study design and Figure 3 provides a timeline of the study activities. See Online appendix A for our pre-analysis plan.

Figure 2: Trial flow diagram

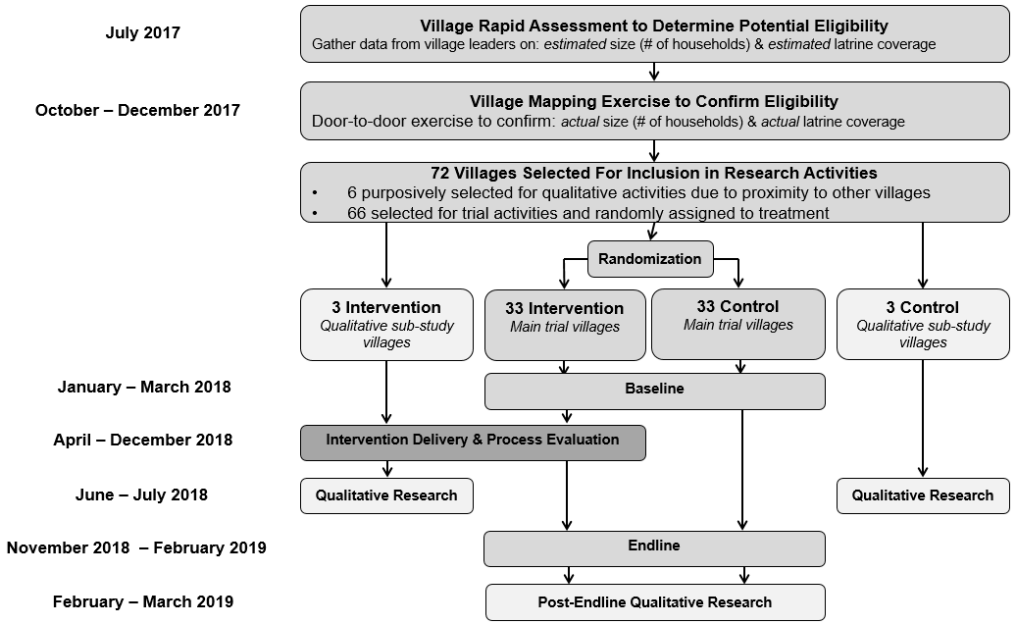
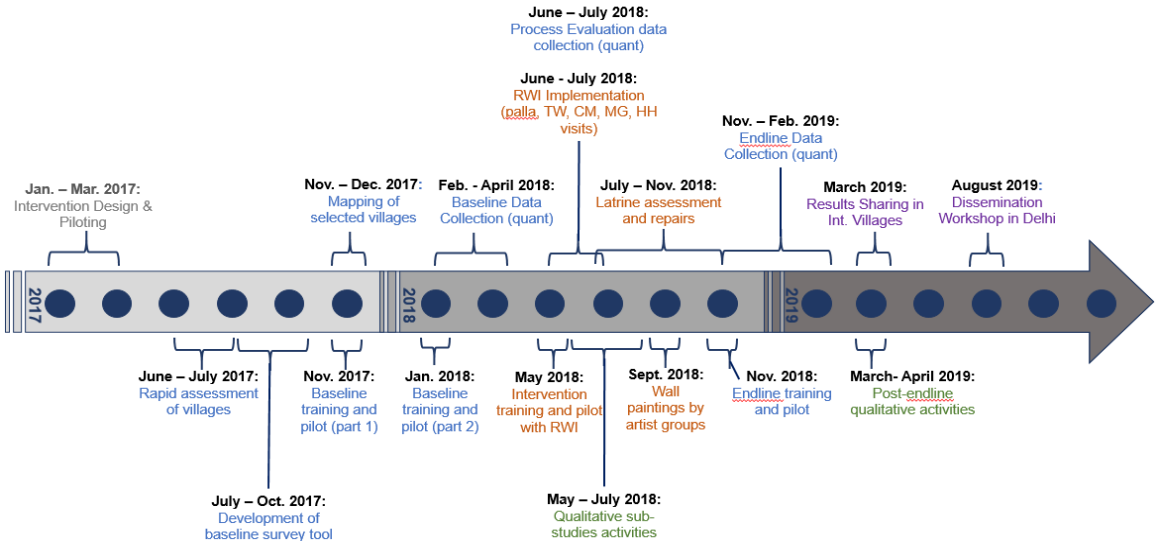


Figure 3: Trial timeline



Notes: TW = transect walk; CM = community meeting; MG = mothers' group; HH = household; quant = quantitative; int = intervention.

3.2.2 Sample size

We identified 72 eligible villages to engage in research activities. Sixty-six villages were included in the main trial (33 intervention and 33 control). The remaining six villages, which were part of a sub-study, engaged in qualitative activities exclusively (three intervention and three control) and did not contribute quantitative data to analyses.

Trial cluster sample size

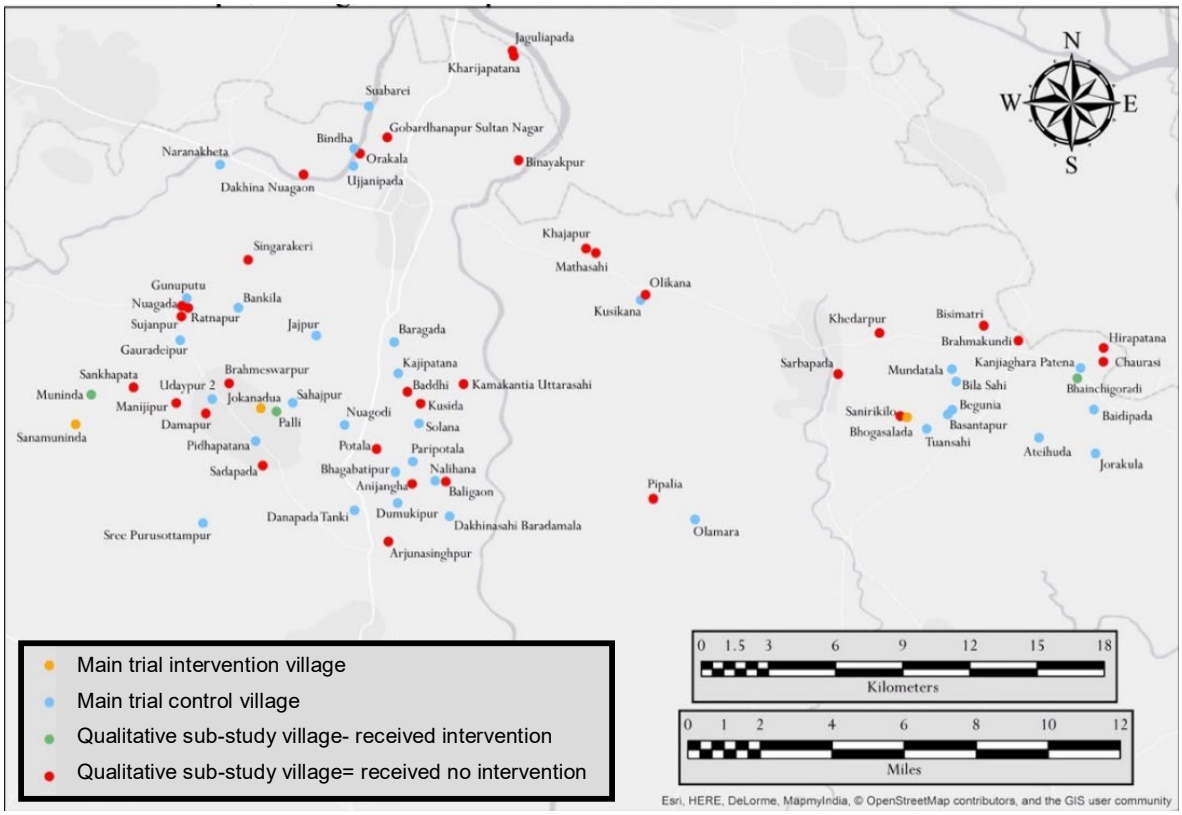
We used the primary outcome of reported latrine use at the last defecation to determine a sample size of 33 villages per arm for the main trial. See Figure 4 for a map of study villages. We used a simulation approach that accounted for baseline assessments of latrine use and adjusted for both within-person and within-cluster correlations (Arnold et al. 2011). Latrine use data collected from 2011 to 2013 during a sanitation trial in Odisha was the source of simulation parameters (Clasen et al. 2014).

Specifically, we assumed baseline latrine use of 45 per cent, a village-level inter-cluster correlation of 0.10, and a within-person correlation from baseline to follow-up of 0.60. We conducted a rapid assessment of villages in the study area in 2017 to estimate latrine coverage.

As no trials have previously investigated the impact of a behavioural intervention designed to increase latrine use amongst households that already owned a latrine, we identified a 10 per cent increase in use (from 45% to 55%) as a minimum intervention effect, under the assumption that the theory-informed behaviour change intervention would have a greater effect on latrine use than interventions that have increased latrine coverage alone.

Garn and colleagues (2017) conducted a post hoc regression analysis and found an increase in latrine use of 5.8% for every 10% increase in latrine coverage. Finally, we assumed villages would have an average of 292 eligible participants for whom latrine use could be assessed (cluster size coefficient of variation = 0.35), 10% loss to follow-up, 80% power, and 0.05 significance level. Sample size estimates were also checked using the 'clustersampsi' add-on package in Stata® version 14 statistical software.

Figure 4: Map of study villages in Pipili, Delang and Nimapara blocks, Puri district, Odisha state



When comparing the estimates that informed our initial sample size calculations with data collected from households surveyed during baseline, we observed a slightly lower average in village size (98 households estimated versus 88 households actual), a higher average in latrine coverage (68% estimated versus 75% actual), and a lower average in the number of persons with latrines per village (292 estimated versus 256 actual).

In addition to updating our estimate based on our baseline enrolment numbers, we used the baseline data to calculate the village-level inter-cluster correlation, which was equivalent to our estimated inter-cluster correlation based on prior work in Odisha (0.10 estimated versus 0.103 actual). However, the proportion of persons reporting using the latrine at baseline was higher than our estimate (0.45 estimated versus 0.60 actual).

Based on our baseline enrolment, unequal cluster sizes with a coefficient of variation = 0.37, baseline latrine use of 60%, and 10% loss to follow-up from baseline to follow-up, **we are powered to detect an absolute difference of 10% as planned (required n = 7,936 individuals per arm)**.

Online appendix F displays the estimated parameters that informed our initial sample size calculations and the actual values from our baseline data collection.

Trial household sample size

In selected villages, all households that owned latrines were eligible for inclusion in the assessment of latrine use among all household members at baseline and endline. Additionally, a subset of 20 households per village were randomly selected to have a

household member complete an assessment of latrine use determinants at baseline and endline, with the aim of having 50 per cent of respondents be female and 50 per cent be male.

Finally, at baseline, all latrine-owning households with children under five were asked to have a primary caregiver complete an assessment of child faeces management practices and answer questions on behavioural determinants. At endline, the same assessment was asked to be completed by caregivers in all households with children under age five, regardless of latrine ownership. However, if a household completed the baseline assessment with a child under five and their child was older at endline, they were still eligible to participate.

Qualitative sample size

The study included two rounds of qualitative research: one right after implementation of activities by RWI (we refer to this qualitative work as the 'sub-study qualitative') and another right after endline data collection was completed (we refer to this qualitative work as the 'post-endline qualitative').

Sub-study qualitative

An additional six villages (three intervention and three control) were engaged in a sub-study involving qualitative research that took place after implementation. We purposively selected three villages from each study arm, with one village from each study block (Pipili, Delang, Nimapara), to provide perspective from each block context. The sub-study had four research aims:

1. To explore community members' perceptions of the Sundara Grama intervention. Listed in Section 2.3 (Intervention monitoring plan) and described in Table 2, this includes the satisfaction element of the process evaluation (e.g. what they liked, did not like, if and how it influenced them) as well as issues related to recruitment and context);
2. To examine spillover effects in control villages (e.g. if men and women in control villages heard anything about the intervention activities, what they may have heard or learned related to latrine use);
3. To explore mothers' perceptions of the child faeces disposal components of the Sundara Grama intervention. As noted in Section 2.3 (intervention monitoring plan), this includes the satisfaction element of the process evaluation (e.g. what they liked, did not like, if and how it influenced them), as well as issues related to recruitment and context); and
4. To explore what implementers (RWI staff) thought of the intervention (e.g. what went well, what did not go well and what would they improve).

The original sample size plan to meet aims 1 and 2 was to conduct 12–18 IDIs with men and women and 6 sex-segregated FGDs with 5–8 participants in each. The original sample size plan to meet aim 3 was to conduct 12–18 IDIs with caregivers and 2 or 3 FGDs in control villages to understand norms around child faeces disposal practices and to explore spillover of the mothers' group meeting (which also met aim 2).

The FGDs for aims 1 and 2 included questions that explored the child faeces disposal components of the intervention (e.g. mothers' group meeting activity), and in this way also addressed aim 3. We aimed to engage several participants from each village by conducting

at least one FGD and several IDIs in each village. The sample sizes were also determined based on an estimate of how many activities and participants were required to fully explore the qualitative research aim and reach saturation of themes across the six villages.

The sample size required to meet aim 4 was 12–16 IDIs with RWI mobilisers and 2–5 FGDs with RWI mobilisers and supervisors. The sample size was determined based on the idea of conducting an interview with each mobiliser to gather individual perspectives and several group discussions to capture shared and differing perspectives on the challenges and success of implementation and again reach saturation of themes.

For more information on the qualitative sub-study sample, please refer to Section 3.4.1 (sample selection).

Post-endline qualitative

A subset of four trial intervention villages was engaged in the qualitative research that took place after endline data collection. The aim of this research was to understand what aspects of the Sundara Grama intervention may be of greatest value (i.e. led to behaviour change), what aspects are not effective (i.e. did not influence behaviour change), and what factors at the individual and community level we did not target effectively or may not be alterable.

The sample size planned was eight sex-segregated FGDs (two per village) and 20 IDIs (five per village), with one participant from each of the five household types from which we aimed to gather perspective. A description of household types is outlined in Section 3.4.1 (sample selection). Again, the sample size was determined in order to ensure that the research aim was explored in each village (i.e. two FGDs per village, five IDIs per village) and to reach saturation of themes.

3.2.3 Randomisation of trial villages

We assigned villages to control or intervention status using stratified randomisation. Whilst there are many potential criteria (such as programmes under which latrines were provided, the proportion constructed with household funds versus government subsidy), we grouped eligible households into four strata based on village size and latrine coverage (median splits). Randomisation was conducted within strata using the Stata® 'randomise' command with the 'block' option and a defined seed to ensure reproducibility.

3.3 Ethics

The Institutional Review Board at Emory University in Atlanta, Georgia and the Ethics Review Committee at Xavier Institute of Management in Bhubaneswar, Odisha, India reviewed and approved study protocols. Trained research assistants read a consent document in Odia, the local language, to all participants. This described the study and objectives prior to any quantitative and/or qualitative data collection activities, and then asked for the participants' verbal consent before continuing. Verbal consent was approved as not all study participants are able to read, particularly women, and therefore may not feel confident signing a document.

All consent documents indicated that participants could cease participation or skip questions at their discretion, and research assistants were trained to respect participants' responses and decisions. Only members of the research team had access to participants' names or other identifying information, with the exception of those participating in FGDs.

In FGDs, we reminded participants that the information they shared would be known to the other participants, and whilst we requested all participants not to repeat shared information outside of the discussion, we warned that we could not control whether or not other participants shared their information and that individuals should participate at their discretion.

All data collectors had prior experience in conducting research and obtaining informed consent from participants. Prior to baseline, all data collectors were retrained on the informed consent process and the particular information sheet and consent for this study.

After endline was completed, research assistants visited all intervention communities to share aggregated findings. In particular, they held meetings at pre-arranged times, open to all community members. At these meetings, the research assistants went through the broad results, sharing information specific to the village, including the number of households and individuals, the number and percentage of households that had latrines, as well as a breakdown by condition (complete, in construction or abandoned) and type (single-pit pour flush or flush to tank).

The research assistants then presented data on latrine use before and after the intervention in that particular village and in aggregate across all intervention villages to enable comparison and discussion. Specifically, research assistants shared the total number of individuals that use latrines (including breakdown by sex and age), the number of households with all members using the latrine, and the number of households reporting disposal of child faeces into the latrine. Community members were then able to ask questions about the findings and share opinions about the data, including their perception of its accuracy.

3.4 Sampling and data collection

3.4.1 Sample selection

Trial village and household selection

We sought villages that were not declared ODF and, to power the study, had a mean size of 100 households (ideally 50–150 households) and a mean latrine coverage of 60 per cent.

To identify eligible villages, we first carried out a rapid assessment of villages in three blocks in Puri district (Delang, Pipili and Nimapada), from June to July 2017. We focused on these blocks due to the ability of our team's and partner's ability to access them for evaluation and intervention delivery. We carried out this exercise – which involved talking with village leaders to gather information – assuming that village sizes and coverage are always changing, that any records available would be dated, and that visiting and talking with village leaders would be able to provide the most up-to-date village information.

We visited a total of 282 villages for the rapid assessment. This list of villages was used as our sampling frame, from which we identified all villages that potentially could be eligible for inclusion. In November and December 2017, these villages were revisited and mapped in order to: (1) confirm the size and coverage numbers originally estimated; and (2) later enable within-village randomisation for administration of specific sub-sections of the baseline survey (if these villages were included in the trial).

A total of 130 villages were mapped, including 115 presumed eligible from the rapid assessment. An additional 15 villages not involved in the rapid assessment were added in order to find enough villages to fit our criteria. Fifty-eight villages were excluded based on their size being too large (n = 9), low coverage (n = 38), being declared ODF prior to baseline (n = 9), or having a large number of hamlets, or hamlets located far from the central part of the village (n = 2).

The remaining 72 were selected to be included in research activities. We first purposively selected 6 villages to engage in the qualitative research (further explained in following section). The remaining 66 selected were engaged in the trial, and have a mean size of 97 households per village (range: 47–132) and a mean latrine coverage of 63% (range: 49–95%). See Table 3 for target and achieved sample sizes for trial.

Trial household selection.

All households with a latrine (regardless of functionality) were eligible for inclusion. Within households, data regarding the last defection event was sought for all permanent household members. This resulted in a baseline enrolment of 3,972 households with latrines (control = 2,045, intervention = 1,927) for a total baseline sample of 16,880 persons over the age of five years (control = 8,654, intervention = 8,226).

Table 3: Target and achieved sample for trial

	Target	Actual, baseline	Actual, endline
Villages	66	66	66
Intervention	33	33	33
Control	33	33	33
Households	All HHs that own latrines in each village	3,978 (4,251 eligible)	4,280 (4,484 eligible)
Intervention	All HHs that own latrines in intervention villages	1,928 (2,077 eligible)	2,100 (2,170 eligible)
Control	All HHs that own latrines in control villages	2,050 (2,174 eligible)	2,180 (2,314 eligible)
Individuals	All individuals from HHs that own latrines in each village	13,406	13,406
Intervention	7,936	6,862	6,862
Control	7,936	6,544	6,544

Sub-study qualitative village and participant selection

The six qualitative villages were purposively selected from the pool of 72 eligible villages. They represent three pairs of villages from three distinct blocks that are within one kilometre of each other. Because of this proximity, we felt that they would not be ideal for the main trial due to the potential for spillover.

In each pair, one village was identified to receive the intervention and one to serve as a control. The proximity, whilst not ideal for the full trial activities, allowed for qualitative assessment of whether or not spillover occurred in the control villages. One of the selected villages was unintentionally engaged in piloting activities, so a new village needed to be selected.

This meant that only two of the three pairs were within one kilometre of each other as planned, enabling a realistic assessment of spillover in only two of the control villages. At the time of the mapping exercise, these six villages had a mean size of 102 households per village (range: 42–154) and a mean latrine coverage of 65 per cent (range: 51–94%), roughly matching the characteristics of the main trial villages.

Target participants for the FGDs (to meet aims 1 and 2, described above in Section 3.2.2) were men and women aged 18 years or over who reported attending several of the Sundara Grama intervention activities. The qualitative research team asked for support from village *anganwadi* (rural child care centre) workers in helping to recruit target participants in advance, as they are often familiar with all households in the village as a result of their work. If the workers were not able to recruit enough participants, they were instead recruited on the day of the FGDs through convenience sampling by going from house to house and snowball sampling.

Target participants for the caregiver IDIs (to meet aim 3, described above) were women who had attended the mothers' group meeting. Since the process evaluation data showed that a wide age range of women attended the mothers' group meeting activity, women in different life stages – from young wives to mature wives and grandmothers – were purposefully targeted.

Recruitment for the IDIs was primarily conducted the day before the interviews. Research assistants again engaged *anganwadi* workers to help identify and recruit mothers to participate. After locating the initial contacts suggested by the *anganwadi* workers, the research assistants conducted snowball sampling from initial contacts or other members of the community to seek out more participants.

Target participants for aim 4 were RWI community mobilisers and supervisors. Our team directly engaged with RWI staff and did not require any specific recruitment strategy. Table 4 shows the target and achieved sample sizes for sub-study qualitative research.

Table 4: Target and achieved sample sizes for sub-study qualitative research

Activity	Target	Actual
IDIs	36 to 52	44
IDIs with community members in intervention villages	6 to 9 (2 to 3 per village)	0*
IDIs with community members in control villages	6 to 9 (2 to 3 per village)	0*
IDIs with women who attended the mothers' group meeting in intervention villages	12 to 18 (4 to 6 per village)	24 9 women (aged 20–29) 9 women (aged 30–39) 1 woman (aged 40–49) 2 women (aged 50–59) 3 women (aged 60–69)
IDIs with RWI community mobilisers	12 to 16	20
FGDs	10 to 14	15

Activity	Target	Actual
FGDs with mothers with children under 5 years in control villages*	2 to 3 (across 3 villages)	4 (across 3 villages)
FGDs with community members in intervention villages	3 (across 3 villages)	4 (2 with men and 2 with women, across 3 villages)
FGDs with community members in control villages	3 (1 across 3 villages)	4 (2 with men and 2 with women, across 3 villages)
FGDs with RWI community mobilisers and supervisors	2 to 5	3

* We ultimately decided that FGDs were the more appropriate qualitative method for exploring aims 1 and 2 since the goal was to understand a *broad range of views and shared perspectives* on the intervention and whether spillover took place. IDIs are more appropriate for gathering perspectives on personal experiences. As a result, we focused data collection efforts on conducting FGDs.

Post-endline qualitative village and participant selection

Four of the main study villages were selected for post-endline qualitative research. The villages represented all three study blocks; had a geographic spread and variety in their percentage change in latrine use (low to high); and had intervention activities implemented by one of each of the four RWI supervisor teams.

Five IDIs and two FGDs were planned for each village. Endline data were used to identify participants for each of the activities.

For IDIs, in each village we sought to engage a household member from each of the five household types:

- *Household with change in latrine use:* None or only a few members reporting use at baseline and all reporting use at endline;
- *Household with **no** change in latrine use:* None or only a few members reporting use at baseline and no change in use at endline;
- *Household with change in child faeces disposal behaviour:* Household did not report practising safe child faeces disposal at baseline but reported practising safe disposal at endline;
- *Household with **no** change in child faeces disposal behaviour:* Household did not report practising safe child faeces disposal at baseline or endline; and
- *Household with a new latrine:* Household did not have a latrine at baseline but had a latrine at endline that they constructed themselves.

For all household types, we used endline data to ensure that the household had reported attending three or more of the intervention activities. For the safe disposal of child faeces IDIs, the target respondent was the mother of the youngest child. For the other IDIs, the target respondent was any adult household member, either male or female, who ideally attended some of the intervention activities. Importantly, whilst endline data were used to target participants, in some cases those interviewed reported different behaviour during the interviews than at baseline. In Table 5, the number of actual respondents engaged is based on what was reported in the IDIs, not at endline.

We ultimately elected not to conduct any IDIs with households that had new latrines at endline, contrary to our original plan. Endline data revealed that latrine construction in intervention and control households was comparable. Thus, we elected to focus efforts on learning more about latrine use and faeces disposal behaviours.

For FGDs, we aimed to have one FGD with women and one with men in each identified village, with a target of 6–8 participants per discussion. Target participants were those who attended intervention activities and thus could offer insights and feedback.

Table 5: Target and achieved sample sizes for post-endline qualitative

Activity	Target	Actual
IDIs	20 (5 across 4 villages)	20
HH with change in latrine use	4 (1 per village)	9
HH with no change in latrine use	4 (1 per village)	3
HH with change in CFD practice	4 (1 per village)	5
HH with no change in CFD practice	4 (1 per village)	3
HH with new latrine at endline	4 (1 per village)	0
FGDs	8 (2 per village; 6–8 participants each)	6
Women only	4 (1 per village)	3
Men only	4 (1 per village)	3

Note: HH = household; CFD = child faeces disposal.

3.4.2 Data description

Trial data collection tools

The quantitative baseline and endline instrument includes the eight sections (A–H) that are described below. The endline instrument included a few additional questions in some of the sections and one entirely new section (Section I) that asked about the intervention activities. Note that if a household was surveyed at baseline, then some sections or parts of a given section were skipped at endline. The information was not necessary to collect again as it was reasonable to expect no change in response (e.g. parts of section B, D and E). For each section, the target respondent and objective is described.

Section A – Determination of census eligibility

Respondents: All households in each community identified as part of the trial were eligible to complete section A, regardless of latrine status, if a member of the household over the age of 18 was home and willing to participate. Female respondents were prioritised.

Objective: The objective of this section was to determine if the household owned their own latrine, which is eligibility criteria for the remaining sections of the baseline tool. Basic demographic information (household size, caste) were also recorded to identify trends in ownership versus non-ownership in the village and amongst all villages collectively.

Endline additions: For households that reported having more or fewer latrines at endline compared with the number reported at baseline, we included a few additional questions that asked why a new latrine had been built or destroyed.

Section B – Household socio-economic status and non-sanitation questions
Respondents: All willing and consented participants in latrine-owning households.

Objective: The objective of this section was to collect expanded demographic information from the participating household (e.g. religion, socio-economic status indicators, occupation, education).

Section C – Latrine use of household members
Respondents: All willing and consented participants in latrine-owning households.

Objective: The objective of this section was to determine latrine use for defecation amongst all household members, including faeces management practices amongst children under five and those who are immobile.

Section D – Household water sources and water, sanitation and hygiene facilities
Respondents: All willing and consented participants in latrine-owning households.

Objective: The objective of this section was to gain information about the household's water, sanitation and hygiene (WASH) facilities, including water source, ownership of a bathing area, support (monetary or material) for latrine construction, and whether the household member was aware of any latrine promotion activities that took place in the community to date.

Section E – Household sanitation (latrine history and sludge management)
Respondents: All willing and consented participants in latrine-owning households.

Objective: The objective of this section was to gain more information about the household's latrine, including condition, if it is currently in use, and pit emptying needs and practices.

Section F – Behavioural determinants: latrine use
Respondents: Using data from a mapping exercise conducted prior to survey administration, households were randomly selected to complete this section of the instrument. Households were randomised using a random number generator in Microsoft Excel® and were then randomly assigned. No more than 20 households were to participate per village. If a male household member was available, he was asked to take part, with the aim of having 10 women and 10 men complete this section per village.

Objective: The objective of this section was to assess various factors, including attitudes, norms, risk perceptions and motivations for using and/or not using their household latrine.

Section G – Behavioural determinants: child faeces disposal
Respondents: At baseline, this included all willing and consented participants in latrine-owning households with children under five, ideally the primary or secondary caregiver. At endline, it included all willing and consented participants in all households in trial villages with children under five *regardless of latrine ownership*, ideally the primary or secondary caregiver.

Objective: The objective of this section was to assess current child faeces disposal practices and various factors, including attitudes, norms, risk perceptions and motivations that influence child faeces management. Information was solicited from *non-latrine-owning households at endline* in both intervention and control villages, as the intervention was open to all caregivers of children under age five, regardless of latrine ownership.

Section H – Latrine spot checks
Respondents: No respondents. Observational data was collected from all households that had a member consent to the baseline survey and agree to have observations conducted.

Objective: The objective of this section was to assess the current status of latrines.

Endline additions: One additional question was added to determine whether or not the pit needed to be emptied.

Section I – Intervention activities
Respondents: All willing and consented participants in latrine-owning households.

Objective: For intervention households, the objective of this section was to determine which intervention activities any member of the household attended (if any), what the respondent remembered about the activity (if the respondent attended), and whether or not the respondent heard or talked about the activity with others. For control households, the objective of this section was to assess spillover. Specifically, participants were asked if they had heard of any of the intervention activities.

Sub-study qualitative data collection tools
The sub-study qualitative research aimed to understand village members' perceptions of the various activities conducted in the sub-study intervention villages, latrine use and safe child faeces management behaviours of community members, and potential spillover in the sub-study control villages. Sub-study tools are described below in Table 6.

Table 6: Sub-study qualitative data collection tools

Tool	Purpose
IDI with women who attended the mothers' group meeting in intervention villages	*To assess:* Mothers' child faeces management practices and their perceptions of the mothers' group meetings, including the education delivery and informational value, and their perceptions and usage or non-usage of the potty and scoop received
FGD with mothers with children under five in control villages	*To assess:* Mothers' child faeces management practices and spillover from intervention villages
FGD with community members in intervention villages	*To assess:* Community members' perceptions of the intervention, including their opinions of each activity, how activities could be improved, and if the intervention had an impact on behaviour in the village
FGD with community members in control villages	*To assess:* Community members' sanitation behaviour, the history of sanitation programmes in the village, and if and what they had heard of the intervention occurring in adjacent villages

Post-endline qualitative data collection tools
The post-endline qualitative data tools were designed to gain additional information about behaviour and understand if, how and why the intervention may or may not have had an influence on behaviour. The tools are described in Table 7.

Table 7: Post-endline qualitative data collection tools

Tool	Purpose
IDIs with adults from latrine-owning households in intervention villages	*To assess:* Women's and men's perceptions of the intervention, and how the intervention may or may not have influenced personal and household latrine use behaviour
IDIs with mothers and/or caregivers of children under age five who do and do not safely dispose of child faeces	*To assess:* Participants' perceptions of the mothers' group meetings (and other intervention components), and how the mothers' group and broader intervention may or may not have influenced child faeces management behaviour
FGDs with community members	*To assess:* Community members' perceptions of the intervention, and if and how the intervention may or may not have influenced latrine use in the community

3.4.3 Quality control

The following quality controls were conducted on the baseline and endline survey data (i.e. quantitative data):

- *Field visits:* The field manager and Dr Parimita Routray, Indian principal investigator, made several field visits at the start of baseline data collection. This was to ensure that data collection protocol was being properly followed by the team and to oversee data collection of some of the new enumerators. Dr Routray conducted field visits at the start of endline data collection, as she did at baseline, to ensure that the protocol was being followed for the same purposes.
- *Accompaniments:* At the beginning of baseline and endline data collection, for the first few weeks, two trained field supervisors observed the data collection of enumerators, identified those who were struggling on certain sections of the survey (whether the behavioural determinants section, the latrine observation or some other specific part) and provided additional support and training. During endline data collection, field supervisors especially observed and provided additional support to the two new enumerators who were not part of baseline data collection.
- *Data entry and data checks:* At baseline and endline, a progress database was maintained, which recorded the number of surveys collected each day and in what village. The field manager and Dr Routray also confirmed in the database each day that all surveys collected on mobile phones were uploaded to our server. The research team then conducted checks on the uploaded data by checking that the number of surveys uploaded for a given village matched the number of surveys recorded in the progress database. At baseline, the research team also examined the length of time each survey took (checking for surveys conducted in less than 15 minutes, which would flag a potential issue during delivery).
- *Data processing:* At baseline, duplicate households within each village were identified. The supervisor's tracking sheet was referred to for each duplicated household to determine the correct household identification number. Households were deleted if no information was found in the supervisor's tracking sheet, or if they were true duplicates. New household identification numbers were created for households that were not on the supervisor's tracking sheet. This data processing also took place at endline.

For qualitative data, names and identifying information were excluded from transcripts to ensure anonymity. Additionally, attempts were made to have sufficient sample sizes to enable triangulation of findings.

3.4.4 Specifications

To evaluate the impact of the intervention on latrine use, we used a general estimating equation (GEE) with robust standard errors to estimate a marginal (population average) model with the general form

$$g\left(E\left[Y_{ij}|x_{ij}\right]\right) = x'_{ij}\beta_{ij}$$

where *g(.)* is the link function, Y_{ij} is the outcome of interest for the *j*th observation in the *i*th cluster, x'_{ij} is a vector of covariates, and β_{ij} is a vector of regression coefficients. We specified an exchangeable correlation matrix as the most plausible and parsimonious choice of working correlation structure, noting that GEE with robust estimation yields valid estimates of model coefficients and standard errors when the correlation structure is mis-specified. We used the difference-in-differences (DID) method (as noted in our pre-analysis plan) rather than simply controlling for the baseline outcome in order to estimate the treatment effect. This resulted in the model specification

$$\begin{aligned}\text{post} - \text{intervention latrine use} = {} & \beta_0 + \beta_1\left(\text{treatment}_{\text{assignment}}\right) + \beta_2(\text{time}) + \beta_3(\text{time} * \text{treatment}) + \\ & \beta_4(\text{age}) + \beta_5(\text{sex}) + \beta_6(\text{male educational attainment}) + \beta_7(\text{female educational attainment}) + \\ & \beta_8(\text{household size}) + \beta_9(\text{household socio-economic status})\end{aligned}$$

where the coefficient β_3(time*treatment) is the estimate of the causal effect.

GEE was chosen to account for the clustered nature of the data arising from the cluster-randomised design. Of the two most widely used approaches to modelling the correlation structure in clustered designs – GEE and multi-level modelling – we choose GEE because: (1) it estimates the population-averaged or marginal effects of the intervention, which are more relevant in the context of a large-scale global health intervention; and (2) it is more robust to mis-specification of the true underlying cluster-correlation structure than multi-level models, which can be subject to substantial bias when the model is mis-specified (Hubbard et al. 2010). That said, as a sensitivity analysis we did fit all models as multi-level models (adjusting for village and household clustering) and did not observe any notable changes in model results.

Initially, we attempted to fit log-binomial DID models with GEE as specified in our pre-analysis plan, but these models failed to converge (a problem frequently noted in the statistical literature). Instead, we fit linear probability models, which in contrast to non-linear DID models allow for a straightforward interpretation of the DID coefficient.

We used robust standard errors given the issues with heteroskedasticity implicit in this approach and examined the marginal probabilities of the outcome for each time*treatment combination in order to ensure that predicted probabilities fell within the unit interval [0,1]. Lastly, we conducted a sensitivity analysis by fitting equivalent logit DID models with GEE. Both the predicted probabilities and significance of model coefficients from those models did not differ substantively from the linear probability models. Our pre-analysis plan is in Online appendix A.

3.4.5 Strategies to avoid bias and address spillover effects

Strategies to avoid bias in quantitative data collection

Our research team took several steps to ameliorate various potential sources of bias. Our outcome measure – which was collectively agreed upon by 3ie, the Research Institute for Compassionate Economics and all four research teams engaged in assessing behavioural interventions on latrine use in India – was deliberately designed to avoid social desirability bias or respondents answering questions about latrine use as they think they should answer them to depict themselves in a positive light.

In an attempt to reduce social desirability bias, we asked enumerators to first say to the respondent: 'I have seen that some people defecate in the open, and some people use the latrine. Now I want to ask about where you and your family members defecate.' By adding this opening phrase, the aim was to indicate that the enumerator was neutral and to reduce perception of there being a 'correct' answer.

In addition, based on feedback from our enumerators, the way in which the latrine use question was administered may have also helped to mitigate response bias. Instead of having each household member come to the enumerator and report their defecation practice, the primary survey respondent was able to report on their behalf. This approach could have helped to mitigate social desirability bias.

We recognise that bias, in the form of measurement error, could have taken place if a respondent reported on their family members' defecation practices, but did not report accurately simply because they did not have accurate information to report. In an attempt to mitigate this form of bias, we aimed to engage female household members to answer questions about family members' latrine use, assuming that they would have the best knowledge of their family members' defecation practices, particularly children.

It is possible that the multiple rounds of surveys on latrine use and OD practices in a relatively short time frame could have led to courtesy bias, or a desire to respond in a way that was not offensive to the enumerator team. Trial households experienced a baseline survey and an endline survey, and possibly a measurement team baseline survey, measurement team endline survey, and post-endline qualitative activities. This means a household could have been approached up to five times in the course of 1.5 years about latrine use.

Social desirability bias, courtesy bias and measurement error all could have resulted in, and may explain, the reported increase in latrine use across intervention and control communities. However, we carried out the same research activities in intervention and control communities so expect equal influence on both arms, if any.

Finally, by the time we were conducting the post-endline qualitative research, we did identify survey fatigue, which occurs when respondents are tired of taking surveys and decline to participate. Specifically, potential participants or their family members expressed frustration that our team was continuing to approach their household to engage in a post-endline qualitative research activity and refused to participate.

In regard to the process evaluation quantitative data, we avoided self-evaluation bias by having the majority of process evaluation data collected by a separate evaluator team rather than members of the implementing team. Based on results from the process

evaluation data (Section 4), it is clear that the enumerators were not biased towards answering that all activities were implemented with full fidelity.

Strategies to avoid bias in qualitative data collection
We avoided social desirability bias in qualitative data collection by developing IDI and FGD guides that included exploratory, open-ended questions that were neutral in tone, did not pose leading questions and did not suggest a right or wrong answer. In addition, during the consent process, research assistants specifically explained to participants that there were no right or wrong answers. Lastly, research assistants were trained to be effective interviewers and facilitators, who do not guide the participant to certain responses but conduct the activities in a neutral way to elicit the participant's true experience.

Strategies to address spillover effects
We attempted to mitigate spillover by mapping our selected villages (using GPS coordinates taken at the centre of the village, roughly) and checking to make sure that there was a buffer of at least approximately one kilometre between all villages before randomisation into the treatment arm.

We assessed spillover in the sub-study qualitative research. We purposefully selected two pairs of intervention and control villages that were in close proximity (less than one kilometre) to understand spillover effects. We found that spillover was variable, as it largely depended on relationships between households from different villages. Spillover only took place in one of the intervention and control village pairs, where control qualitative participants largely knew only about the *palla* and transect walk activities.

We also assessed spillover quantitatively by asking control households in the endline survey whether or not activities had taken place in their village. We did not find any evidence to suggest spillover was an issue (Table 8 in Section 4.1.1).

4. Findings

4.1 Intervention implementation fidelity

Below we report on intervention reach, fidelity, dose, recruitment and context.

4.1.1 Intervention reach
Intervention reach was assessed during intervention delivery and at endline.

At endline, 85 per cent of households surveyed from the intervention villages reported that there had been an intervention of any kind in their village since April 2018, compared with just 3 per cent of households in the control villages. Those who reported that activities had taken place were then asked to report what the activities were without being offered response options. Respondents in the intervention communities who reported that activities to encourage latrine use had taken place in their village since April 2018 identified the *palla* performance most often (94%), followed by the transect walk (46%), community meeting (42%), the mothers' group (35%) and household visits (35%).

Only 14% of respondents reported having seen the wall paintings, and 11% reported that latrine repairs had taken place. Out of all respondents from intervention households, 80% reported that the *palla* had taken place, 39% the transect walk, 36% the community meeting, 30% the mothers' group, 12% the wall painting and 9% latrine repairs.

Table 8: Endline participant reporting of intervention activities

	Intervention (n = 2,820)		Control (n = 2,960)	
	number	%	number	%
Have activities to encourage latrine use taken place in the village since April 2018?				
Yes	2,395	85%	81	3%
No	425	15%	2,879	97%
Activities reported to have taken place (by those who reported that activities did occur) *(list not read to participant)*				
	(n = 2,395)		(n = 81)	
Palla performance	2,252	94%	29	36%
Transect walk	1,106	46%	3	4%
Community meeting	1,007	42%	27	33%
Household visits / poster	843	35%	2	2%
Wall painting	337	14%	0	0%
Mothers' group	840	35%	1	1%
Latrine repairs / latrine assessments	267	11%	0	0%
Visit from government official	5	0%	12	15%
Media campaign (TV, newspaper, radio)	1	0%	1	1%
Other	11	0%	9	11%

Note: Total n = 5,780 households, including those without latrines.

Of the 81 respondents in the control villages who said that a latrine use intervention activity had taken place since April 2018 (3% of respondents), the most commonly reported activities included (without prompting) the *palla* (36%), community meetings (33%) and visits from government officials (15%). Out of all respondents from control households, only 1% reported that a *palla* had taken place, 1% reported that a community meeting had taken place, and less than 0.5% reported a visit from a government official. It is likely that the 1% of participants in the control community that reported *palla* and community meeting activities heard about these events occurring in intervention villages.

From data collected during intervention delivery, we gave each village reach scores based on estimated attendance (Section 2.3). The reach score for the mothers' group was the highest (8.7, or 87% of targeted participants attended), distantly followed by the *palla* (2.82), community meeting (1.27) and transect walk (1.03) (Table 9).

As reported in Table 10, at endline 66% of survey respondents reported having heard the intervention motto. The most commonly attended intervention activity by at least one member of intervention households was the *palla* (66%), followed by the community meetings (39%), transect walk (27%) and mothers' group meeting (26%).

However, mothers' group attendance was 96% amongst households with children under five. In total, 64% of respondents indicated that a community mobiliser had conducted a household visit in their household. Only 13% indicated that they had seen the wall painting; of those, 23% were male and 10% were female. We expect that restrictions on women's mobility likely explains why a greater proportion of men saw the wall painting.

At endline, we asked all households that were selected to receive repairs whether or not they had had any latrine repairs completed. Of the 403 intervention households selected to receive repairs (19% of the latrine-owning households at baseline), 272 (67.5%) reported having received the repairs, which is equivalent to 13 per cent of all latrine-owning households in the intervention villages.

Table 9: Reach and fidelity/dose scores of community activities from observations across all 36 villages

	Reach score*		Fidelity/dose score			
	Mean	SD	Max possible	Mean	SD	%
Palla	2.82	0.94	14.00	10.68	1.91	76%
Transect walk	1.03	0.30	11.00	8.25	1.54	75%
Community meeting	1.27	0.45	20.00	13.89	1.34	69%
Mothers' group	8.70	2.82	16.00	12.97	1.52	81%

Notes: SD = standard deviation. * Max reach score is 10 for all activities.

Table 10: Reach of community activities as reported by respondents from intervention communities in the endline survey

	N	%
Recall hearing intervention motto	1,860	66%
Someone in household attended:		
Palla	1,853	66%
Transect walk	775	27%
Community meeting	1,088	39%
Mothers' group (amongst all households)	728	26%
Mothers' group (amongst households with children under five)	728	96%
Household visit conducted		
Yes	1,814	64%
Refused visit	21	1%
Respondent has seen wall painting	358	13%

Note: n = 2,820 households, including those without latrines.

4.1.2 Intervention fidelity/dose

Intervention fidelity/dose was assessed during intervention delivery by Emory process evaluation team members. Fidelity/dose scores are presented in Table 9.

For the *palla*, the mean fidelity/dose score was 10.68 out of 14, indicating that 76% of all components were delivered as planned. Across the villages, 35% of *pallas* left out messaging about the importance of male latrine use, 35% did not discuss the need for men to be role models in their household, 42% forgot messaging about safely disposing of child faeces into a latrine as a means of keeping children healthy, 50% did not mention that Odisha has one of the highest rates of OD, 62% did not indicate that work time would not be lost to sickness if people used latrines, and 65% did not discuss that money can be saved from illness-related costs if all household members used the latrine.

We engaged two different troupes to perform the *pallas*. We explored whether or not their faithfulness to the script and the messages varied. Specifically, we ran a t-test on the overall scores and found a significant difference in the scores for the two troupes (95%,

confidence interval [CI] -3.763 to -1.581, p = < .001). The mean score for Troupe 1 was 9.38 and the mean score for Troupe 2 was 12.053.

It seems Troupe 1 most often missed messaging comparing the perceived benefits of OD with the benefits of latrine use, as well as messaging about pit emptying. Overall, Troupe 2 performed almost every *palla* message every time whilst Troupe 1 varied greatly.

For the transect walk, the mean fidelity/dose score was 8.25 out of 11, indicating that 75 per cent of all components were delivered as planned. In 31 per cent of villages, community mobilisers did not close the meeting with a statement of encouragement about the community's ability to become ODF, like other villages in Odisha.

For the community meeting, there were supposed to be two community meetings per village – one for women and one for men – to create environments that enabled female attendance and participation. Due to resource constraints (time, funds allowable for intervention activities) in all villages there was only one meeting, open to both men and women. In total, there were 1,245 participants in community meetings, including 598 women (48%), 403 men (32%), 118 boys under the age of 18 (9%) and 134 girls under the age of 18 (11%). There was an average of 34 attendees per meeting (11 men, 16 women, 3 boys, 4 girls).

The mean fidelity/dose score for the community meeting was 13.89 out of 20, indicating that 69 per cent of all components were delivered as planned. There were key behaviour change technique elements that were not completed in a majority of community meetings. Specifically, whilst nearly all meetings (97%) discussed challenges to latrine use, only 53 per cent followed with a discussion of solutions to the challenges, potentially having a detrimental effect. Additionally, an activity intended to inspire the village to be a 'model' village had numerous components missing.

For the mothers' group meeting, the mean fidelity/dose score was 12.97 out of 16, indicating that 81 per cent of all components were delivered as planned. Observation revealed that there was a high rate of participation in discussions; however, community mobilisers did not engage participants well in opportunities to practise using the hardware, and only 75 per cent of meetings included a planned action planning segment.

Finally, messages about how to handle child faeces if households did not own a latrine were missed. Notably, only 78 per cent of meetings discussed the importance of burying water used to wash materials/hardware tainted with child's faeces if the household did not own a latrine and only 61 per cent discussed the need to bury child faeces if a household did not have a latrine.

A desk review of household visit log sheets revealed that the three components of the visit were carried out in nearly all intervention households. All wall paintings had the three necessary elements: the village map with houses, the clearly identified positive deviant households, and the action steps decided upon by the village during the community meetings.

For latrine repairs, we asked households that had reported having repairs done what they had had repaired. Doors were the most common repair (57%), followed by fixes to flooring (21%), pit lining (19%), slab covers (15%) and pipe connections (14%) (Table 11).

Table 11: Types of repairs reported at endline

Repair type	Number of repairs	Repaired latrines (%)
Door	155	57%
Roof	0	0%
Walls	2	1%
Slab cover	40	15%
Pan	13	5%
Pipe connection	38	14%
Pit lining	52	19%
Flooring	57	21%
Parapet	1	0%
Other	8	3%

Note: Multiple repairs possible per household; n = 272 repairs.

4.1.3 Intervention recruitment and context

The qualitative research in the sub-study villages and main trial villages at endline, and post-endline community meetings, revealed issues with attending the activities, specifically the community-level activities, and the potential for ration cards to be taken away if people were caught practising OD.

For the *palla*, transect walk and community meetings, some participants indicated that they did not know about the activities. Those that did not know about the activities typically indicated that community mobilisers did not go to 'their side' of the village to tell them about the activities. In these cases, there is a clear issue of recruitment, and community mobilisers should have made sure that all parts of the village were aware of the activities.

In other instances, recruitment efforts were made, but village dynamics impeded participation. Specifically, some participants indicated that they were not able to attend activities. Whether because of caste or 'tension', divisions in villages existed. If an activity was in a location associated with one 'side' of the village, non-occupants felt that they could not attend. When we piloted in early 2017, we also had an incident where half of a village did not attend because of reported 'tensions'.

Anticipating the social dynamics within the villages themselves, community mobilisers were instructed to make visits to the villages and meet with various stakeholders prior to starting activities. These visits were meant to identify if duplicate activities should occur in different parts of the village. In four villages, additional *palla* performances were scheduled to accommodate different parts of the villages. We did not follow up or ask what the specific dynamics of what some of these 'tensions' were.

Women also reported barriers to attending activities, primarily related to social context. Some women indicated that community level activities, like the *palla*, were scheduled when they had household work to complete, which prevented their participation. Other women indicated that they could not attend activities where their father-in-law or brothers-in-law were in attendance.

Anticipating that women may not attend or participate in community meetings, the intervention was designed to have sex-segregated community meetings to enable attendance; however, only one meeting was completed per village due to constraints on time and funds.

Surprisingly, women also faced barriers to attendance to the mothers' group meeting. The mothers' group meetings were designed for mothers and caregivers of children under five. Often, the women in attendance were mothers-in-law. Whilst we did not collect data on the roles of the women in attendance (e.g. mother, mother-in-law), we found that 36 per cent of attendees were older than 45 years, which we assume (with some exceptions) were mothers-in-law. Families would not permit their daughters-in-law to leave the house. Interviewed daughters-in-law, who had a mother-in-law attend the meetings, said that their mothers-in-law shared the hardware with them, but often failed to pass on any of the relevant information.

Finally, both the qualitative data from sub-study villages that received the intervention, and notes from the post-trial sharing meetings, revealed that people had heard rumours that ration cards could be taken away if people were caught practising OD. In the two sub-study qualitative intervention villages, ration cards were discussed differently in each one.

In one, participants reported that someone was seen practising OD during the transect walk and a male told her that she could have her ration card taken away. It remains unclear who the male was. In the other village, taking ration cards was brought up by participants as a potential strategy to enforce latrine use in their community, although it is unclear whether they came up with this idea or had heard it being a tactic used elsewhere.

During the post-endline sharing meetings, participants from four main trial intervention villages also noted that they had heard ration cards could be cancelled if people were caught openly defecating. In one of these villages, a participant noted that this rumour seemed to have stopped people from practising OD for a few days. Overall, as we did not collect systematic data on this topic, we do not have a sense of how widespread these rumours were, by whom the messages were delivered, when (before, after, or even during intervention activities) these messages were delivered and heard, who heard these messages, whether or not they were believed, or the extent to which they may have influenced behaviour. Still, this information is important contextual information to share and could be investigated further.

4.1.4 Intervention satisfaction

Participant satisfaction varied. In reference to the intervention overall, several participants in qualitative interviews and discussions and those who commented during the community meetings indicated that the repetition of messages through the various activities was important, and many suggested repeating some of the activities, particularly the *palla*.

Overall, participants enjoyed the *palla* activity, commenting on how entertaining and funny it was, although some shared that they did not think it provided them with any additional information to what they knew already. Participants thought that the transect walk was memorable, although some noted that it induced sentiments of shame, disgust and even fear.

Perceptions of the community meetings were variable. Some village members were positive and indicated that the meeting inspired their community to clean up parts of their village. Others indicated that their village would never be able to change or work together because of pre-existing tensions.

With regard to the mothers' group, participants and those who had received materials from other members in their household who had attended, had varied opinions of the supplies. Several women discussed problems with the potties: they could only be used for kids of a certain age, children could not defecate well on them in a sitting position, they were hard to clean, they broke, their kids did not like them or fought over them. The potties seemed only to have worked for some households.

Scoops were described as more useful, as they could be used for picking up faeces when children defecated in the open, and some women got their children to defecate directly onto them. Regardless of methods used, women discussed the time-consuming nature of cleaning the hardware, raising questions about whether or not this was done as expected. Some women used paper to cover the potty and scoop, but then just tossed the faeces-soiled paper in their trash piles.

Households that reported having received repairs to their latrine reported their satisfaction with them via the endline survey. Of the 113 respondents who provided answers, 75 per cent indicated that they were satisfied or completely satisfied (Table 12).

Table 12: Satisfaction with latrine repairs

	n	%
Completely satisfied	36	32%
Satisfied	49	43%
Somewhat satisfied	23	20%
Not at all satisfied	5	4%

Note: n = 113 respondents.

4.2 Impact analysis

4.2.1 Descriptive statistics

Trial participants

The trial study population includes 36 *gram panchayats* and 66 villages across intervention and control communities. At baseline, 5,864 households and 20,370 individuals were represented and 85.7 per cent of primary respondents were female (Table 13). Amongst those with at least one latrine at baseline, the predominant religion was Hindu (95.5%), whilst only 2.9 per cent of households identified as Muslim (Table 14).

The majority of households reported their caste/tribe as 'other' (43.3%), since most households report their surname as their caste and do not identify with one of the government categories. As such, we marked these responses as 'other' but also recorded the surname provided. These surnames were then recategorised into one of the government categories based on official government documents.[1]

After recategorising, 41.4% of households were identified as other backward castes, 35.7% general caste, 12.1% scheduled caste, 1% scheduled tribe, 8.1% other, and 1.6% not applicable. Three quarters (75.1%) of households received some sort of government funding, be it BPL assistance or Antyodaya and/or ration cards. With regard to education,

[1] We referred to documentation provided by India's Ministry of Social Justice and Empowerment to identify caste categories: http://socialjustice.nic.in/UserView/index?mid=76750.

38.9% of male head of households had completed secondary education or higher and 10.6% had never attended school. In contrast, 20.6% of female head of households had completed secondary education or higher, whilst 29.7% had never attended school.

Table 13: Characteristics of the full trial sample (census population)

Census population (all households surveyed)			
	Intervention	Control	Total
Villages	33	33	66
Households censused	2,846	3,018	5,864
Population censused	9,922	1,0448	20,370
Households per village	86.2 (25.4)	91.5 (24.6)	
Population censused per village (mean [SD])	300.7 (102.8)	316.6 (104.9)	
Population censused per study arm (%)			
Female†	4,482 (49.8)	4,770 (50.4)	9,252
Male†	4,514 (50.2)	4,687 (49.6)	9,201
Under 5 years of age	531 (5.9)	543 (5.7)	1,074
Sex, primary respondent (n = 5,864) (%)			
Female	2,439 (85.7)	2,581 (85.5)	5,020
Male	407 (14.3)	437 (14.5)	844
Caste / tribe of household (n = 5,864) (%)			
Brahmin	293 (10.3)	180 (6.0)	473
General	675 (23.7)	713 (23.6)	1,388
Scheduled caste	254 (8.9)	235 (7.8)	489
Other backward caste	419 (14.7)	508 (16.8)	927
Scheduled tribe	28 (1.0)	12 (0.4)	40
Other	1,174 (41.3)	1,366 (45.3)	2,540
Don’t know	3 (0.1)	4 (0.1)	7

Notes: SD = standard deviation. † All ages.

Table 14: Characteristics of the baseline sample

Baseline study population (eligible households with at least one latrine)			
	Intervention	Control	Total
Households eligible	1,928	2,050	3,978
Religion of household (n = 3,977) (%)			
Hindu	1,854 (96.2)	1,944 (94.9)	3,798
Hindu/Muslim	2 (0.1)	0 (0)	2
Hindu/other	0 (0)	2 (0.1)	2
Muslim	42 (2.2)	72 (3.5)	114
Christian	1 (0.1)	0 (0)	1
Buddhist/Neo-Buddhist	1 (0.1)	1 (< 0.1)	2
No religion	6 (0.3)	9 (0.4)	15
Other	22 (1.1)	21 (1.0)	43
Government subsidies (n = 3,977) (%)			
BPL	143 (7.4)	181 (8.8)	324
BPL/antyodaya	10 (0.5)	11 (0.5)	21
BPL/antyodaya/ration card	60 (3.1)	56 (2.7)	116
BPL/ration card	319 (16.5)	299 (14.6)	618
Antyodaya	121 (6.3)	108 (5.3)	229
Antyodaya/ration card	29 (1.5)	38 (1.9)	67
Ration card	753 (39.1)	857 (41.8)	1,610
None	482 (25)	489 (23.9)	971
Don't know	11 (0.6)	10 (0.5)	21
Education of male head of household (n = 3,820)			
Anganwadi	76 (4.1)	66 (3.4)	142
Primary	426 (23.0)	446 (22.7)	872
Upper primary	344 (18.6)	360 (18.3)	704
Secondary	527 (28.4)	570 (29.0)	1,097
Senior secondary	77 (4.2)	84 (4.3)	161
Graduate/post-graduate	112 (6.0)	116 (5.9)	228
Never attended	184 (9.9)	219 (11.1)	403
Don't know	108 (5.8)	105 (5.3)	213
Education of female head of household (n = 3,925)			
Anganwadi	60 (3.2)	65 (3.2)	125
Primary	560 (29.4)	562 (27.8)	1,122
Upper primary	306 (16.1)	330 (16.3)	636
Secondary	301 (15.8)	350 (17.3)	651
Senior secondary	40 (2.1)	51 (2.5)	91
Graduate/post-graduate	40 (2.1)	25 (1.2)	65
Never attended	561 (29.5)	605 (29.9)	1,166
Don't know	35 (1.8)	34 (1.7)	69

Note: Total n = 3,978 households.

On average, at baseline 63.7% of households in intervention villages and 67.3% of households in control villages reported owning at least one latrine. The majority of latrines were flush to pit (73.1%), fully constructed (87%), did not require repairs (68.6%) and were reported to be used for defecation (75.9%) (Online appendix K).

In the baseline study sample, 77.3% of households reported that they had received money and/or materials to construct their latrine, 65.1% of households received assistance from SBM, and 25.5% reported that their latrine construction was entirely self-financed. Only 4.7% of households reported that their latrine pit had ever filled. Amongst these, 73.5% reported that the pit was then emptied. Based on surveyor observation, 41.1% of households had a handwashing station in or near their latrine and 68.7% had a water source within 30 feet of their latrine (Online appendix K).

Sub-study participants

As part of a sub-study, 152 adults participated in FGDs to gain perceptions of the intervention (in intervention communities) and spillover (in control communities). Approximately half (47%) were women, 43% were from control villages, 66% reported owning a latrine and, of those, 87% reported using the latrine at all times (Online appendix L).

Sixty-one women participated in IDIs (n = 24, all from intervention villages) and FGDs (n = 37, all from control villages) to understand their perceptions of the mothers' group activity (in intervention communities) and spillover (in control communities). Fifty-nine per cent reported owning a latrine and, of those, 42 per cent reported using the latrine at all times (Online appendix M).

4.2.2 Balance tables

Table 15 shows the balance between control and intervention arms at baseline. Latrine use (control: 61.7%; intervention: 60.4%) and safe child faeces disposal (control: 3.4%; intervention: 6.0%) were nearly identical. Half of the population in the sample is female, the mean age is 20, the mean household size is 4.7, and most people are other backward caste followed by general caste (Table 15). Household water and sanitation-related characteristics of the full study population at baseline, including latrine type, latrine-funding source, and information about pit emptying can be found in Online appendix K.

4.2.3 Research analyses

Primary outcome

Our primary research question for this evaluation was: is latrine use amongst people who own a latrine in communities that received the intervention significantly different at endline from that amongst people who own a latrine in communities that did not receive the intervention?

We hypothesised that latrine use and safe disposal of child faeces amongst people in households that own a latrine in villages that received the intervention would be significantly higher than amongst people in latrine-owning households in control villages.

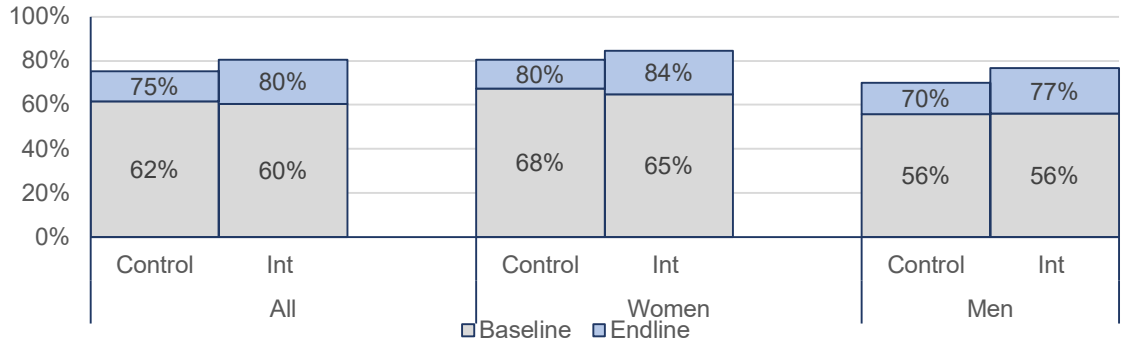
Our intention-to-treat (ITT) analysis revealed an increase in reported latrine use amongst individuals aged five years and over of 6.4% (95% CI 2.0–10.7%, p = .004) in the intervention group at endline, after accounting for the increase in latrine use observed in the control group (Table 16).

There was an increase in latrine use in both intervention and control villages at endline compared with baseline. Latrine use increased in control villages by 13 percentage points (from 62% to 75%) and in intervention villages by 20 percentage points (from 60% to 80%). The increases in proportions of men and women using latrines were comparable

across both arms. Men had a slightly higher percentage-point increase in both control (14 points) and intervention villages (21 points) compared with women (control: 12 points; intervention: 19 points). However, more women (control: 80%; intervention: 84%) than men (control: 70%; intervention: 77%) were reported to use latrines in either arm at endline (Figure 5).

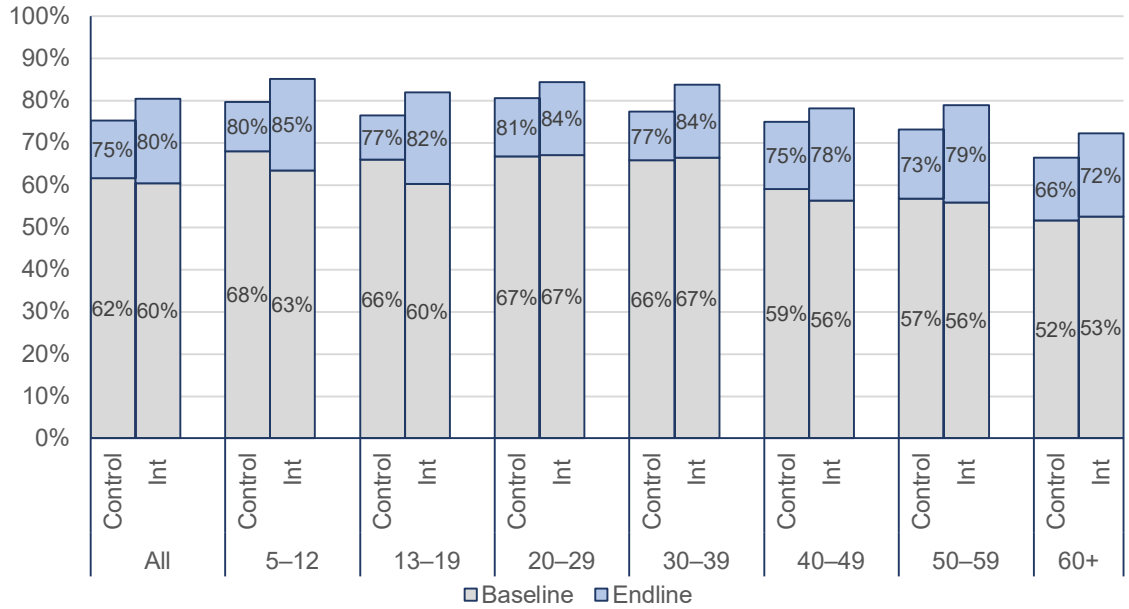
Across the different age categories, the increases in the proportion of use ranged from 17% to 23% in the intervention villages and from 11% to 16% in the control villages. The smallest increase in the intervention villages (17%) was amongst 20–29 and 30–39 year olds, who had the greatest proportion of use at baseline. The greatest increase in the intervention villages (23%) was amongst 50–59 year olds, who had a low proportion of use at baseline (56%). Those aged 60 and over had the lowest proportion of use in intervention villages, and had a moderate (19 percentage points) increase in use. This age set continues to have the lowest proportion of latrine users overall (Figure 6).

Figure 5: Proportion of individuals (aged 5+) from latrine-owning households who used a latrine at last defecation, by sex



Note: Int = intervention.

Figure 6: Proportion of individuals (aged 5+) from latrine-owning households who used a latrine at last defecation, by age category



Note: Int = intervention.

Table 15: Baseline balance: Individual and household characteristics

	Control		Intervention		
	Mean or n	SD or %	Mean or n	SD or %	Std diff
Individual (n = 13,812)					
Latrine use					
Yes	4,231	61.7	3,954	60.4	0.03
No	2,631	38.3	2,590	39.6	
Safe child (under-5) faeces disposal					
Yes	7	3.4	12	6.0	0.13
No	200	96.6	187	94.0	
Female	3,477	50.7	3,263	49.9	0.01
Male	3,385	49.3	3,281	50.1	
Age	36.1	20.4	36.2	20.38	-0.01
Age category					
0–4	207	2.9	199	3.0	0.07
5–12	726	10.3	719	10.7	
13–19	844	11.9	699	10.4	
20–29	1,216	17.2	1,171	17.4	
30–39	992	14.0	1,061	15.7	
40–49	1,043	14.8	983	14.6	
50–59	901	12.7	835	12.4	
60+	1,140	16.1	1,076	16.0	
Household (n = 3,305)					
Household size	4.7	2.0	4.7	1.9	
Caste					
General caste	554	33.1	598	38.4	0.18
Scheduled caste	182	10.9	207	13.3	
Other backward caste	764	45.7	589	37.8	
Scheduled tribe	10	0.6	19	1.2	
Not applicable	28	1.7	21	0.3	
Other	134	8.0	124	8.0	
SES quintile					
Quintile 1	323	19.0	296	18.5	0.08
Quintile 2	363	21.3	300	18.7	
Quintile 3	345	20.2	316	19.7	
Quintile 4	344	20.2	343	21.4	
Quintile 5	329	19.3	346	21.6	
Education of male HH head (grade)	7.5	4.1	7.5	4.2	0.00
Education of female HH head	5.2	4.2	5.2	4.2	0.00

Notes: SD = standard deviation; Std diff = standardised difference; HH = household; SES = socio-economic status.

Table 16: Effect of intervention on latrine use

	Effect size	SE	95% CI%	p-value
DID	0.06	0.02	0.02–0.11	0.00
Intervention arm	-0.01	0.03	-0.08–0.05	0.67
Baseline latrine use	0.14	0.01	0.11–0.16	0.00
Number of HH members	-0.01	0.00	-0.01–0.00	0.03
SES				
Quintile 1	*Ref*			
Quintile 2	0.09	0.02	0.04–0.13	0.00
Quintile 3	0.15	0.02	0.11–0.20	0.00
Quintile 4	0.24	0.02	0.20–0.28	0.00
Quintile 5	0.33	0.02	0.28–0.37	0.00
Sex				
Male	-0.09	0.01	-0.11 – -0.08	0.00
Female	*Ref*			
Education of male HH head (grade)	0.01	0.00	0.01–0.01	0.00
Education of female HH head	0.00	0.00	0.00–0.01	0.00
Age category				
5–12	0.04	0.01	0.02–0.06	0.00
13–19	0.04	0.01	0.01–0.06	0.00
20–29	0.04	0.01	0.02–0.06	0.00
30–39	*Ref*			
40–49	-0.03	0.01	-0.05 – 0.00	0.03
50–59	-0.05	0.01	-0.07 – -0.02	0.00
60+	-0.09	0.01	-0.11 – -0.07	0.00
Intercept	0.45	0.04	0.37 – 0.52	0.00

Notes: SE = standard error; HH = household; SES = socio-economic status. Adjusted for clustering, ITT analysis.

Our ITT analysis revealed an increase in reported safe disposal of child faeces of 20.4% (95% CI 11.7–29.2%, $p < .001$) in the intervention group at endline, after accounting for the increase in safe disposal of child faeces observed in the control group (Table 17).

Table 17: Effect of intervention on safe disposal of child faeces

	Effect size	SE	95% CI%	p-value
DID	0.20	0.04	0.12–0.29	0.00
Intervention arm	0.03	0.02	-0.02–0.07	0.23
Baseline safe disposal	0.07	0.02	0.04–0.11	0.00
Number of HH members	-0.01	0.01	-0.02–0.00	0.05
SES				
Quintile 1	*Ref*			
Quintile 2	0.07	0.04	-0.01–0.15	0.67
Quintile 3	0.07	0.04	0.00–0.14	0.54
Quintile 4	0.12	0.04	0.05–0.19	0.00
Quintile 5	0.17	0.04	0.09–0.25	0.00
Sex				
Male	-0.01	0.02	-0.05–0.04	0.73
Female	*Ref*			
Education of male HH head (grade)	0.00	0.00	0.00–0.01	0.34
Education of female HH head	-0.01	0.00	-0.01–0.00	0.11
Intercept	0.01	0.04	-0.07–0.09	0.76

Notes: SE = standard error; HH = household; SES = socio-economic status. Adjusted for clustering, ITT analysis.

Secondary outcomes

Latrine construction

We hypothesised that latrine construction amongst non-latrine owners in villages that received the intervention would be significantly higher compared with those residing in control villages.

We found no difference between intervention and control villages in the proportion of households that did not have a latrine at baseline and had one at endline (6.77% in control; 6.96% in intervention; p = .903).

Behavioural determinants

We hypothesised that latrine use behavioural determinant scores would be significantly higher at endline amongst latrine owners in intervention villages compared with latrine owners in control villages. We aimed to have 20 randomly selected respondents from latrine-owning households in both intervention and control communities, with 10 being female and 10 being male, at both baseline and endline (1,320 at both baseline and endline: 660 in intervention and 660 in control villages). A total of 1,251 households completed behavioural determinant surveys (control: 625, intervention: 626). However, of those, only 810 (65%) households had the same respondent at baseline and endline (control: 398, intervention: 412).

We created scores from items representing each of the six behavioural determinants: ability (5 items), motivation (4 items), physical opportunity (2 items), risk perception (3 items), self-regulation (5 items) and social norms (7 items). All items for ability, motivation, physical opportunity, risk perception and social norms had four potential response options

to indicate the level of agreement. These were: completely agree (1), mildly agree (2), mildly disagree (3), and completely disagree (4). Self-regulation items also had four possible responses for each item.

One item assessed level of agreement as previously described, whilst the remaining four items assessed level of intention (1 item), level of commitment (1 item) and level of confidence (2 items). Items were recoded as needed such that valence would be consistent. To create scores, we simply summed each item in the domain and divided by the number of items to arrive at scores that could range from 1 (optimal score, highest level of agreement) to 4 (least optimal score).

Consistent with our model approach, we fit a linear DID model with robust standard errors and adjusting for age, sex, household size, socio-economic status, and education of male and female heads of household. Only 729 (58%) respondents had complete behavioural determinants and covariates.

Scores were similar at baseline and endline for all behavioural determinants. Most determinants (ability, motivation, physical opportunity, risk perceptions and social norms) had scores in the 1.3 to 1.7 range, indicating general agreement with the questions posed. Self-regulation scores ranged from 2.3 to 2.4, indicating responses were between mildly agree and mildly disagree (Table 18). We found no increase in reported scores at endline as hypothesised (Table 19).

We ran GEE models to test the association of each individual behavioural determinant on latrine use, adjusting for respondent age, sex, household size, and male and female head of household education attainment. Physical opportunity, ability and social norms scores were all significant predictors of latrine use as hypothesised (favourable scores were associated with latrine use) (Table 20). Scores for motivation, risk perception and self-regulation were not.

Table 18: Behavioural determinant scores at baseline and endline

Determinant	Baseline				Endline			
	Intervention		Control		Intervention		Control	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Self-regulation	2.3	0.3	2.4	0.3	2.4	0.3	2.4	0.3
Physical opportunity	1.7	1.0	1.7	1.0	1.5	0.9	1.5	0.9
Ability	1.7	0.5	1.7	0.5	1.6	0.5	1.6	0.5
Social norms	1.6	0.5	1.7	0.5	1.5	0.4	1.5	0.4
Motivation	1.4	0.5	1.4	0.5	1.3	0.4	1.3	0.4
Risk perception	1.7	0.7	1.9	0.8	1.7	0.7	1.7	0.8

Note: SD = standard deviation. N = 729.

Table 19: Effect of intervention on behavioural determinant scores*

DID	Effect size	SE	CI	p-value
Physical opportunity	0.99	0.083	0.84–1.16	0.888
Ability	1.28	0.048	0.93–1.13	0.600
Social norms	1.02	0.042	0.94–1.11	0.620
Motivation	1.00	0.042	0.92–1.09	0.969
Risk perception	1.15	0.078	0.98–1.34	0.079
Self-regulation	1.01	0.035	0.94–1.08	0.788

Notes: SE = standard error. * Models adjusted for age, sex, household size, socio-economic status, sex, and education of male and female household heads.

Table 20: Association of behavioural determinants on latrine use at endline*

DID	Odds ratio	SE	CI	p-value
Physical opportunity (n = 899)	0.46	0.03	0.40–0.54	0.000
Ability (n = 899)	0.70	0.10	0.53–0.92	0.010
Social norms (n = 899)	0.32	0.06	0.21–0.47	0.000
Motivation (n = 899)	0.84	0.17	0.56–1.25	0.384
Risk perception (n = 899)	0.84	0.12	0.64–1.11	0.228
Self-regulation (n = 901)	1.37	0.26	0.94–2.00	0.099

Notes: SE = standard error. * Models for each behavioural determinant run independently and are adjusted for age, sex, household size, socio-economic status, and education of male and female household heads.

4.2.4 Heterogeneity of impacts

Additionally, whilst we were not powered to carry out subgroup analyses, we also present models stratified by gender.

Our ITT analysis revealed an increase in reported latrine use amongst females aged five years and over of 6.6 per cent (95% CI 2.2–11.0%, p = .003) in the intervention group at endline, after accounting for the increase in latrine use observed in the control group (Table 21).

Our ITT analysis revealed an increase in reported latrine use amongst males aged five years and over of 6.1 per cent (95% CI 1.3–10.8%, p = 0.011) in the intervention group at endline, after accounting for the increase in latrine use observed in the control group (Table 22).

Table 21: Effect of intervention on latrine use amongst females

	Effect size	SE	95% CI%	p-value
DID	0.06	0.02	0.02–0.11	0.00
Intervention arm	-0.03	0.03	-0.09–0.04	0.42
Baseline latrine use	0.13	0.01	0.10–0.16	0.00
Number of HH members	-0.01	0.00	-0.01–0.00	0.03
SES				
Quintile 1	*Ref*			
Quintile 2	0.09	0.03	0.04–0.14	0.00
Quintile 3	0.17	0.02	0.12–0.21	0.00
Quintile 4	0.24	0.02	0.20–0.29	0.00
Quintile 5	0.32	0.02	0.27–0.37	0.00
Education of male HH head	0.01	0.00	0.01–0.01	0.00
Education of female HH head	0.00	0.00	0.00–0.01	0.03
Age category				
5–12	0.02	0.02	-0.01–0.05	0.16
13–19	0.06	0.01	0.03–0.09	0.00
20–29	0.06	0.01	0.04–0.08	0.00
30–39	*Ref*			
40–49	-0.01	0.01	-0.04–0.02	0.57
50–59	-0.05	0.02	-0.08 – -0.02	0.00
60+	-0.08	0.02	-0.11 – -0.05	0.00
Intercept	0.45	0.04	0.37–0.53	0.00

Notes: SE = standard error; HH = household; SES = socio-economic status. Figures adjusted for clustering, ITT analysis.

Table 22: Effect of intervention on latrine use amongst males

	Effect size	SE	95% CI%	p-value
DID	0.06	0.02	0.01–0.11	0.01
Intervention arm	0.00	0.04	-0.07–0.07	0.92
Baseline latrine use	0.14	0.01	0.12–0.17	0.00
Number of HH members	-0.01	0.00	-0.01–0.00	0.04
SES				
Quintile 1	*Ref*			
Quintile 2	0.08	0.03	0.03–0.13	0.00
Quintile 3	0.14	0.02	0.09–0.19	0.00
Quintile 4	0.24	0.02	0.20–0.27	0.00
Quintile 5	0.33	0.03	0.28–0.38	0.00
Education of male HH head	0.01	0.00	0.01–0.01	0.00
Education of female HH head	0.00	0.00	0.00–0.01	0.00
Age category				
5–12	0.05	0.02	0.02–0.09	0.00
13–19	0.02	0.02	-0.02–0.05	0.37
20–29	0.03	0.02	0.00–0.06	0.07
30–39	*Ref*			
40–49	-0.05	0.02	-0.08 – -0.02	0.00
50–59	-0.05	0.02	-0.08 – -0.01	0.01
60+	-0.10	0.02	-0.13 – -0.07	0.00
Intercept	0.35	0.04	0.27–0.43	0.00

Notes: SE = standard error; HH = household; SES = socio-economic status. Figures adjusted for clustering, ITT analysis.

5. Cost analysis

5.1 Cost of the Sundara Grama intervention

The Sundara Grama intervention cost US$42,065.29 to roll out across 36 intervention villages (33 for the main trial, 3 for the sub-study) over a period of 8 months (1 month for training, 1.5 months for software activities, and another 5.5 months for latrine assessments and repairs). See Table 23 for a summary of intervention costs and Online appendixes G, H and I, for detailed descriptions of programme administration, staff training and implementation costs.

Table 23: Summary of intervention costs

Item	Budgetary total (Rs.)	Budgetary total (US$)	Unit	Unit cost (Rs.)	Description
Programme administration	1,017,800.00	14,540.00	-	-	20 RWI staff hired for 3 months, office rental for 3 months, office stationery for 3 months, office organisation for 3 months
Staff training	131,303.20	1,875.76	-	-	20 RWI staff trained on all intervention activities during the course of 12 training days, which included both in-house and field practice. All staff provided with printouts of intervention materials (manual, facilitator guides, logsheets) and organisational folder to safely keep materials
Staff transportation	141,960.00	2,028.00	-	-	20 RWI staff provided with transportation stipend to cover cost of travel to intervention villages during implementation
Palla performances	422,233.36	6,031.91	43 *palla* performances	9,819.38	43 *palla* performances implemented at a cost of Rs9,803.26/performance
Transect walks	7,630.00	109.00	36 transect walks	211.94	36 transect walks implemented at a cost of Rs211.94/walk for activity materials
Community meetings	1,146.68	16.38	36 community meetings	31.85	36 community meetings implemented at a cost of Rs10.83/meeting for activity materials
Mothers' group meetings	232,754.00	3,325.06	36 mothers' group meetings	6,465.39	36 mothers' group meetings implemented at a cost of Rs6,382.33/meeting for activity materials
Household visits	159,359.00	2,276.56	2,189 posters	72.80	2,189 household posters printed at a cost of Rs72.80/poster
Wall paintings	360,000.00	5,142.86	36 wall paintings	10,000.00	36 wall paintings implemented at a cost of Rs10,000/painting
Latrine assessments	48,815.00	697.36	815 latrines assessed	59.90	815 latrines assessed at a cost of Rs59.90/latrine
Latrine repairs	421,569.00	6,022.41	457 latrines repaired	922.47	457 latrines repaired at a cost of Rs922.47/latrine
TOTAL	**2,944,570.24**	**42,065.29**			

The intervention specifically targeted households that had a latrine before implementation (i.e. when asked in the baseline survey). The 36 intervention villages consisted of 2,173 households with at least one latrine. The cost of the intervention per *targeted* household was US$19.36 (Table 24). We also calculated the cost of the intervention per household *reached*.

The 33 trial intervention villages included 2,828 households. Amongst these households, 2,520 (89%) reported attending at least one of the six software intervention activities. As such, the cost of the intervention per household *reached* was US$16.69. This cost is slightly inflated, as the cost of the intervention includes all 36 intervention villages but quantitative data on activity attendance was only collected in the 33 trial intervention villages (as three intervention villages only had qualitative data collection).

In addition, the exposure to the intervention measure only accounts for the software activities and does not include the approximately 457 households that also received latrine repairs. With an 89 per cent exposure to software activities, however, it is very likely that these households are already accounted for in the exposure denominator.

Table 24: Cost of intervention per household type

Total cost of intervention = US$42,065.29	N	Cost per HH (US$)
Intervention households	3,205	13.12
Reached households (i.e. attended at least 1 activity)	2,520	16.69
Targeted households (i.e. with latrine)	2,173	19.36

Note: HH = household.

5.2 Cost-effectiveness of the Sundara Grama intervention

We conducted a cost-effectiveness analysis of the Sundara Grama intervention. The analysis was restricted only to those households that had a latrine and provided self-reported latrine use behaviour at both baseline and endline (n = 3,723 households).

First, we examined how different exposure levels to the intervention had an impact on household latrine use. During endline data collection, intervention households were read a description of a given software activity and then asked, ‘Did you or other members in your household attend X?’ The total number of activities attended was then tallied to determine an ‘exposure level’.

Households were categorised as having null/low exposure to the intervention if the household attended 0 or 1 activity (427 households, 23.7%), medium exposure for attending 2 or 3 activities (855, 47.4%), and high exposure for 4 to 6 activities (521, 28.9%); control households were automatically categorised as null exposure.

The measure of effect was based on whether or not a household reported improved latrine use – that is, the household reported more members using the latrine at endline than baseline. In total, 894 intervention households improved their latrine use and 770 control households improved their latrine use.

We then calculated the inter-quartile unadjusted odds ratios. Households with a high exposure to the intervention had 1.71 times the odds (95% CI 1.32–2.21) of improving

their latrine use when compared with households with null/low exposure, and 1.28 times the odds (95% CI 1.03–1.60) when compared with households with medium exposure (Table 25). As expected, we found even higher odds of improving household latrine use when comparing intervention households with high or medium levels of exposure against control households with null exposure to the intervention (high exposure versus null control = odds ratio 1.88; 95% CI 1.54–2.28; medium exposure versus null control = odds ratio 1.46; 95% CI 1.24–1.72).

The incremental cost-effectiveness ratio of the Sundara Grama intervention was calculated based on a total implementation cost of US$42,065.29 and dividing by an effect on 894 intervention households (i.e. improving latrine use). The Sundara Grama intervention has a ratio of US$47.05 per household – that is, a cost of US$47.05 to improve latrine use of one household that experiences some level of exposure to the intervention.

Table 25: Impact of intervention exposure on the odds of improved household latrine use

	Intervention exposure	Odds ratio	95% CI	p-value
Intervention HHs only	Medium vs. null/low	1.331	1.05–1.68	0.0083
	High vs. medium	1.282	1.03–1.60	0.013
	High vs. null/low	1.706	1.32–2.21	< 0.0001
Control HHs (null) vs. intervention HHs of certain exposure level	Null/low vs. null (control)	1.099	0.89–1.36	0.1922
	Medium vs. null (control)	1.462	1.24–1.72	< 0.0001
	High vs. null (control)	1.875	1.54–2.28	< 0.0001

Note: HH = household.

6. Discussion

6.1 Discussion overview

We found a reported increase in latrine use amongst individuals aged five years and over of 6.4 per cent (95% CI 2.0–10.7%) in the intervention group at endline, after accounting for the increase in latrine use observed in the control group. An increase in control communities is not surprising. Given the current push by the government to declare India ODF by 20 October 2019, a reported increase in use across the country is expected.

Even though only three per cent of respondents from control villages reported that activities took place *in their villages* in the preceding year, it is highly likely that other campaigns that were not ‘in the village’ influenced use across both arms, including radio, television and newspaper campaigns, as well as campaigns that targeted urban areas that rural residents visited.

We expected changes to occur in both control and intervention villages, and our study was designed to detect a difference in intervention arm villages despite increases in latrine use reported in both intervention and control villages. Whilst not a large effect size, our findings demonstrate that the intervention did influence reported use. The intervention resulted in a greater increase in use than would have occurred if the

intervention had not taken place. Villages in rural Odisha have been recipients of sanitation interventions for decades, with mixed results, and the fact that this trial found the intervention to have had an impact is promising.

A stratified analysis revealed that the increases in latrine use were comparable amongst females (6.6%, 95% CI 2.2–11.0%, p = .003) and males (6.1%, 95% CI 1.3–10.8%, p = .011). Our intervention aimed to increase latrine use by all and deliberately included messaging and activities that targeted both men and women. For example, in our formative research, we learned that not all household members, including both men and women, knew how to use their latrines or that defecating in the open could pollute the environment and harm health.

In the *palla*, we deliberately included skits that had demonstrations of how to use the latrine and that humorously depicted how flies could be deadly transmitters of faecal pathogens when faeces were in the environment. The *palla* also included messages specifically targeting men, encouraging them to be role models for other men in the community by using the latrine. For women, the *palla* also acknowledged that OD is often a time to connect with other women but pointed out that finding other places and reasons to walk and talk would be less dirty.

In the spirit of increasing latrine use for all, our intervention also aimed to increase the safe disposal of child faeces. We found a reported increase in the safe disposal of child faeces of 20.4 per cent (95% CI 11.7–29.2%, p < .001) in the intervention group at endline, after accounting for the increase in safe child faeces disposal observed in the control group.

To our knowledge, this is the first evaluation of an intervention specifically designed to increase faeces disposal. Many mothers indicated that they did not realise the importance of safely disposing of child faeces. We believe that simply enabling caregivers to understand the importance of disposing of faeces in the latrine contributed considerably to reported changes in behaviour.

Despite impact, our robust, mixed-methods process evaluation revealed that specific intervention components, including recruitment, reach, fidelity and satisfaction of each of the community activities, could be improved to potentially achieve greater impact. At endline, we learned that 66 per cent of households said that they had one member attend the *palla* and 80 per cent reported, without prompting, that the *palla* took place in their community, indicating reach was strong, but could also be improved. Fidelity scores for this activity were also strong. Most importantly, participants discussed enjoying the *palla* performance, remembering several key stories that communicated health messages and the importance of a clean village, and wanting to see the *palla* again.

People also recalled the transect walk, either because it illuminated their understanding of the condition of their village or because it caused them to feel shame and disgust at the filth. The qualitative sub-study helped to reveal that this activity also has the potential to be harmful. When done early in the morning, people may be caught in the act of defecating, an experience which could be particularly detrimental to women (Routray et al. 2015; Caruso et al. 2017; Sahoo et al. 2015). Holding the walk at a different time could eliminate the risk of causing harm. Additionally, because the transect walk is

inexpensive and does not have to be intrusive, it could be rolled out more frequently to allow for more frequent assessment of, and reflection about, the village condition.

The community meetings and household visits were not delivered as originally designed because of time constraints. Further, not all of the behavioural techniques planned for the community meetings were delivered as planned. Still, some community members reported changes in their village, like cleaning parts for alternative uses, that resulted from the action planning in the meetings. Participants discussed how they did not know they could come together in such a way.

Members of other villages commented that tensions are so high in their villages that any collaboration would be unlikely. These mixed findings illuminate the importance of context. The success of an intervention strategy that emphasises key motivators at the community level, such as status and cleanliness and beauty, may not be possible in villages that do not have a sense of collective identity and pride. In villages that may be more receptive, additional intervention components that serve to strengthen collective efficacy may be useful (Delea et al. 2018).

We learned that the wall painting, intended as a reminder of the community action plan and an inspiration to attain positive deviant household status, was not seen by many households, particularly women who have little mobility outside the house. If adapting the intervention, we would consider eliminating the map to divert time and resources to strengthening reach, the content of the community meeting and household visits, and re-introducing sex-segregated community meetings to each village to enable greater access and participation of women.

Our intervention did not include a heavy focus on pit emptying. From our formative research, we did not find concerns about pit emptying to be an impediment to latrine use amongst those we engaged, which is contrary to what has been found in other Indian states (Coffey et al. 2017). In the present study, only 5% (189) of the baseline population reported having had a full pit, and of those 86% practised healthy behaviours: 74% (138) emptied their pits and 12% (22) switched to or built a new pit. Only 13% (25) restricted household members' use or stopped using altogether (Online appendix K).

We do acknowledge that pit emptying is an important consideration for the sustainability of latrine use, and do not deny that pit emptying may be a concern in the coming years as households continue to use their latrines. To this end, the *palla* performances did include some messages about pit emptying.

With regard to safe disposal of child faeces, the specific contribution of hardware, and potties in particular, needs further investigation. From the qualitative research, we know that the potties were not universally used or liked, whether because they were not appropriate for all ages of children in the household or they broke and caused more challenges for mothers.

Whilst we managed to reach nearly 96 per cent of eligible households through the mothers' group activity, through our qualitative work we realised that we were not reaching *mothers of small children* directly. Many households sent other family members to the meetings and mothers reported not being allowed to attend. It is conceivable that the intervention could have had greater impact if strategies were employed to ensure the

greater participation of mothers, or if the activity was modified to have specific messages for grandmothers, given that they were common proxy attendees.

We found no difference in behavioural determinant scores amongst intervention and control villages at endline compared with baseline. It is possible that our intervention did not improve these behavioural determinants as expected. It is also possible that the measures we created to assess change could have been improved, or that we did not have a sample large enough to detect a difference.

There was no difference in latrine construction at endline amongst non-latrine-owning households in intervention villages compared with controls. This finding is not surprising, as our intervention was not designed to motivate an increase in latrine construction. Our finding that latrine coverage increased at a similar rate across study arms suggests that background sanitation efforts we were unaware of may have been under way across the study area.

Construction efforts can contribute to increases in latrine use. In an ad hoc analysis, Garn and colleagues (2017) found a 5.8 per cent increase in use for every 10 per cent increase in latrine coverage. The Research Institute for Compassionate Economics found that, whilst a reduction in OD was observed between 2014 and 2018 in Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh amongst rural households, the proportion of latrine owners practising OD during that time period remained the same. This suggests that reductions in OD were likely driven by latrine coverage increases alone (Gupta et al. 2019).

Our analysis only includes households that had latrines at both baseline and endline, thus the increase in latrine coverage in both arms does not explain the increases in use observed in our sample. Further analysis of our data is needed to determine the proportion of members using latrines in households that have constructed latrines since baseline.

6.2 Policy and programme relevance: evidence, uptake and use

We engaged three key types of stakeholders: researchers (as well as donors), practitioners and community members. Below we describe the strategies used to engage these stakeholders and the resultant impacts.

6.2.1 Research stakeholders (researchers, donors and implementing partners)

We engaged researchers in the sanitation and public health fields by participating in a number of workshops and conferences. We presented at the Social Norms Workshop hosted by PENN SoNG, the 3ie Delhi Evidence Week, the Tech4Dev Conference hosted by UNESCO, and presented multiple times at the Water and Health Conference hosted by the University of Chapel Hill.

By engaging and presenting at these workshops, we were able to shed light on the dearth of rigorous trials that examine changes in WASH behaviours with *behaviour* as the primary outcome. We emphasised the importance of investing in behaviour change intervention design and evaluation, and how the 3ie Thematic Window 14 is a much-needed start. We believe such engagement helped to sustain momentum for these types of behavioural impact evaluations and to communicate to both researchers and donors the need for such investments and continued learning.

Our presentations also highlighted the current 'black box' of intervention design. They explained how the public health field needs to do a better job of showcasing *how* interventions are designed, and what evidence and theory they are based upon (if used). We were able to offer a tangible example by showcasing our team's process of applying behavioural theory and conducting formative research to then design the Sundara Grama intervention in Phase 1 of this grant.

We also shared our intervention design process at the Social Norms Workshop and 3ie Delhi Evidence Week, which included a diverse audience of researchers, donors and practitioners. Many audience members approached us after the presentation to continue the discussion, demonstrating the interest that varied stakeholders have in learning more about intervention development.

Finally, we will continue to engage research stakeholders through future publications and conferences. In this way, we will continue to shape the sanitation and public health fields by offering lessons learned and future directions. For example, we plan to showcase the impact evaluation findings as well as our rigorous process evaluation findings, emphasising the importance of such data to work in concert to better inform policy and practice.

6.2.2 Community stakeholders

The community results-sharing meetings were a successful stakeholder engagement activity for community members. As described in Section 3.3 (ethics), in each of the 33 trial intervention villages we held a community meeting wherein Emory research assistants shared the overall impact results, as well as changes in latrine use and safe disposal of child faeces behaviours specific to that particular village. A banner was used to share the findings and acted as an effective visual aid (Online appendix J).

The research assistants walked through each of the numbers displayed on the banner and checked with community audience members that the information was clear. The facilitated discussion at the end of the meeting was also an effective way to create space for reflection and elicit feedback from community members on both their village-specific results and the intervention activities. Some key takeaways from the feedback discussions are noted below:

- Transect walks are an effective technique for initiating re-evaluation of the environment and, as such, reflections of shame and disgust. At many of the community meetings, villagers discussed the impact of the transect walk. Whilst some villagers did not like the activity and felt it was disrespectful, most villagers thought that the activity was effective and 'motivating'.
- Effective sanitation behaviour change programmes must involve continued engagement of communities. At some of the community meetings, villagers discussed how the repeated visits by mobilisers, as well as the survey team, caused them to continue to reflect on the OD in their village and feel a sense of shame. Villagers discussed that the repeated visits were motivating their fellow community members to change their behaviour.
- Overall, the community meetings highlighted a mixed response as to whether the Sundara Grama intervention was effective in changing latrine use behaviour.

Whilst we are not able to follow up, we believe the meetings will likely have an impact on community members in the future. Local stakeholders such as ward members now have

an understanding of their village's latrine use compared with neighbouring villages, and as such may continue efforts towards improving their village's sanitation. Moreover, the reflection discussions provided important insights into intervention activities and elucidated recommendations for future iterations of the intervention, should it be implemented again. In many ways, we found the debrief notes on these discussions to be just as rich, if not more so, than the data from the post-endline qualitative research.

6.2.3 NGO/practitioner stakeholders

We heavily engaged with the Orissa-based NGO Gram Vikas throughout our impact evaluation. Gram Vikas just entered their fifth decade of community development work and plan to develop various WASH-related behaviour change interventions moving forward. As such, after Phase 1, we reached out to the organisation and presented to Director Liby Johnson and other Gram Vikas staff our process for applying behavioural theory and formative research to intervention design, and how we used this process to develop the Sundara Grama intervention.

We then collaborated with Gram Vikas and 3ie team members on a measurement, evaluation and dissemination for scale learning exchange funded by the Bill & Melinda Gates Foundation. The goal of the learning exchange was to explore what worked and what did not work when it came to latrine use behaviour change interventions in rural Odisha – comparing and examining the Emory Sundara Grama intervention and the Gram Vikas framework called MANTRA (Movement and Action Network for Transformation of Rural Areas). This was another successful engagement with Gram Vikas as we continued to share lessons learned from our different experiences in intervention design.

We are now working with Gram Vikas on a future study that will use a similar intervention design process as the one we used for Sundara Grama. We will design a behaviour change programme that promotes safe child faeces management practices amongst households with small children in MANTRA villages. This study collaboration developed in part from our continued and successful stakeholder engagement activities with Gram Vikas over the past two years. Moreover, findings from our impact evaluation – especially findings on the mothers' group meeting activity, which focused on safe child faeces management practices – will be used to inform aspects of this future study.

6.3 Challenges and lessons

Identifying villages for evaluation

Whilst we invested our own resources in terms of time, capacity and funds to identify appropriate villages with a rapid assessment before funding was awarded in June/July 2017, we needed to invest additional time from October to December to map all potential villages to ensure that they fit the eligibility criteria. Specifically, we needed to confirm that coverage and size were adequate to ensure that we were adequately powered. This consumed both time and resources. We will take this as a lesson learned and plan for a mapping phase in future studies.

Limited time frame for evaluation and intervention activities

The limited time frame for completing all activities posed challenges. First, it would have been ideal to collect baseline and endline data exactly one year apart. Mapping delayed

the baseline, so the window between data collection events was narrowed. In addition, due to the limited time frame, study households were engaged several times within a short period of time, especially intervention households, which could have led to participant fatigue. In fact, during recruitment of post-endline qualitative participants, some households expressed frustration and anger at being engaged again on the topic of sanitation.

Intervention households in particular experienced multiple activities: a baseline survey, a measurement team baseline survey, intervention activities, possibly qualitative activities, an endline survey, a measurement team endline survey, and possibly post-endline qualitative activities. A household could have been approached seven or more times in the course of 1.5 years about latrine use.

We could not resolve this challenge, and simply take it as an important reflection to consider in future studies. Ultimately, all the engagement activities were important, but a wider window of time for activities may have enabled greater success, particularly with post-endline qualitative activities.

Resource constraints for implementation
As described previously, we were not able to roll out the household visits as originally intended due to resource constraints. Specifically, training and roll-out of the other intervention activities took longer than expected. As such, there was limited time for the household visit activity and we could not employ RWI staff for a longer period due to the US$20 cap on the intervention cost.

To resolve this challenge, we revised the household visit so that it consisted of only three key activities and took approximately 10 minutes to deliver (a very brief visit). The lesson learned is that there is always a fine balance between the time and financial constraints of a programme and the ideal programme activities. When having to revise behaviour change programme activities, we needed to carefully consider which behaviour change techniques should remain and which could be cut.

Enabling environment for latrine use behaviour (i.e. functional latrines)
We felt that it was important to include latrine repairs as part of the intervention since we knew from past research that many government-built latrines are often in disrepair and not functional. In addition, based on behavioural theory, it is imperative that the enabling environment is in place when trying to change a behaviour. Otherwise, the environment poses another barrier to the behaviour. As such, we spent considerable time and resources on the latrine repairs.

Whilst this activity was successful, it pulled time and funds from the behaviour change activities. However, it was also a policy-relevant component. As India continues to increase sanitation coverage and use, there will be a need to continue investment in sustaining both facilities and behaviour to ensure that any progress towards an ODF India are maintained.

Seasonal variation
It is important to consider how seasonal variation can influence study activities. We tried to avoid having any research activities – including data collection or intervention delivery – take place during extremely hot summer or monsoon seasons. However, the mapping

exercise that we undertook at the outset of the study to identify eligible villages took longer than expected and pushed our timeline back. Intense heat and rain can interrupt or slow study activities. Most importantly, data collection at baseline and endline should occur in similar seasons, if not exactly a year apart, so that variation in climate is not a factor influencing the outcome of interest.

Information asymmetry
Residents of the intervention villages likely received asymmetric information because of their ability and/or willingness to attend the intervention activities. This is true even for the mothers' group meetings, which were the most well-attended. We know from the qualitative research as part of the process evaluation that mothers-in-law or other family members sometimes attended on behalf of mothers.

We opened the meeting to caregivers to enable our reach to extend to all households with children under five. However, the qualitative research revealed that the mothers who had someone attend on their behalf may or may not have received any of the information or messaging about the importance of safe child faeces disposal. In other words, the person who attended did not always tell mothers about what was learned at the meetings.

Hardware distribution strategies
It is important to be mindful of community members' expectations when distributing hardware to them, and to anticipate and plan for any potential challenges. As part of our intervention, we distributed potties and scoops to facilitate child faeces disposal. We planned for mothers and caregivers who had attended the meeting (which instructed those present on safe use and care) to receive the hardware after the meeting. In some instances, people heard about the hardware in advance and just wanted to come to take the items and leave, or men in the community came just to collect the hardware. Also, in some villages, *anganwadi* workers wanted some hardware for themselves. We had not anticipated these challenges and had to devise plans to ameliorate tensions with community members, if they resulted.

7. Conclusions and recommendations

Our theory-based intervention increased latrine use and safe disposal of child faeces in intervention villages compared with controls. Our process evaluations demonstrated that fidelity was strong, but can be improved. Efforts to reach participants, particularly women, can also be strengthened, potentially further increasing the impact of the intervention on both behaviours.

Moving forward, we offer the following recommendations for key stakeholders in the realm of sanitation and behaviour change:

- Policymakers: We recommend that policymakers recognise that behaviour change takes time and is 'a moving train'. That is, behaviour change programmes should seek to catalyse the *initial* adoption of a behaviour but also the long-term *maintenance* of the behaviour. We believe sanitation, and latrine use in particular, should be viewed as a long-term, continuous investment. As such, in addition to further investment to make sure that those who have yet to change behaviour and use the latrine for all defecation purposes, the government should invest in strategies to maintain the progress made thus far.

Specifically, to sustain latrine use and make sure that latrine users do not revert to OD, continued programming is needed to make sure that users remain motivated and convinced by behaviour change messages and that latrines themselves are useable. Latrines will always need to be repaired – whether due to expected wear or from unexpected events like cyclones – and people will need resources and support to fix them. Further, if used as expected, latrines will need to be emptied. In Puri, Odisha, single pit latrines were the most common. People in Puri will need support, whether guidance or resources, to empty latrines in the years to come if they are still to be used.

This recommendation comes from our findings, which highlight the variability of households and individuals in their history of practising latrine use – namely how some consistently practise latrine use and others do not. As such, it is not enough to view behaviour change programmes as a 'one-time' need. Our extensive investment in repairing latrines further supports this point. Latrine construction has been considered a one-time investment by the government. No mechanisms exist to support households to fix their latrines if they break, or even to get them into working order if built poorly.

- Programme managers: We recommend that programme managers are trained to understand the behaviour change techniques being employed in each intervention activity. This recommendation comes from our experience training RWI staff and the findings from the process evaluation data, which show key behaviour change techniques were not effectively employed. It is possible that RWI staff did not have a strong understanding of how the activities should operate. NGO programme staff often have past work experience implementing behaviour change programmes.

  However, many behaviour change programmes focus solely on knowledge dissemination and general awareness campaigns. As such, it is imperative to adequately train programme managers when behaviour change interventions employ a more diverse and complex set of behaviour change techniques. In this way, programme staff are able to truly understand the goal of the activity and how it should operate. This will ensure behaviour change interventions are implemented with fidelity.

  We also recommend that programme managers, particularly those delivering interventions at a village or community level, invest time in understanding any village dynamics that may have an influence on programme delivery. During the formative research that preceded this trial, we found that one village had unexplained 'tensions' that prevented some members from attending, and that another village prevented women from attending public events, like the *palla*. We had community mobilisers make an initial visit to meet stakeholders who may be able to participate in activities, and to identify any potential community dynamics that may have an influence on the intervention delivery.

  Despite this effort, more time meeting with stakeholders would have been beneficial. When we shared results with community members, we learned that some villages had members who did not benefit from activities because they did not know they had occurred or were not permitted to attend.

- Programme participants: We recommend that programme participants are actively engaged in the piloting, process evaluation and results sharing of behaviour change programmes, as they are often the true experts in identifying why a programme activity is successful or unsuccessful. The formative research phase that preceded this trial, the qualitative research in the sub-study villages, and the post-endline qualitative research all enabled invaluable opportunities to collect insights from participants. They provided critical reflections that improved our understanding of the programme and how we would change future iterations of the programme, if given the opportunity.
- Researchers: We recommend that researchers conduct qualitative sub-studies and a rigorous process evaluation in order to have a rich understanding of how a behaviour change intervention was actually implemented (i.e. fidelity of the treatment) and to better understand the impact evaluation results. This type of data also offer rich findings on which aspects of the intervention were successful or unsuccessful, thereby providing more fruitful findings for future researchers and practitioners alike.
- Donors: We recommend that donors invest more time and funding in the intervention design process. The WASH field still does not have a good grasp on which behaviour change techniques are effective at changing WASH behaviours, or which communication channels are best for delivering those techniques (e.g. community-level activities, group discussions, household visits). As such, providing adequate time and funding will better ensure that effective behaviour change interventions are designed and subsequently worth evaluating through rigorous impact evaluations.

Online appendixes

Online appendix A: Pre-analysis plan

https://www.3ieimpact.org/sites/default/files/2019-09/TW14.1006-Online-appendix-A-Pre-analysis-plan.pdf

Online appendix B: Fidelity/dose scoring for the *palla*

https://www.3ieimpact.org/sites/default/files/2019-09/TW14.1006-Online-appendix-B-Fidelity-Dose-Scoring-for-the-Palla.pdf

Online appendix C: Fidelity/dose scoring for the transect walk

https://www.3ieimpact.org/sites/default/files/2019-09/TW14.1006-Online-appendix-C-Fidelity-Dose-Scoring-for-the-Transect-Walk.pdf

Online appendix D: Fidelity/dose scoring for the community meeting

https://www.3ieimpact.org/sites/default/files/2019-09/TW14.1006-Online-appendix-D-Fidelity-Dose-Scoring-for-the-Community-Meeting.pdf

Online appendix E: Fidelity/dose scoring for the mothers' group

https://www.3ieimpact.org/sites/default/files/2019-09/TW14.1006-Online-appendix-E-Fidelity-Dose-Scoring-for-the-Mother%E2%80%99s-Group.pdf

Online appendix F: Estimated and actual parameters informing sample size calculations

https://www.3ieimpact.org/sites/default/files/2019-09/TW14.1006-Online-appendix-F-Estimated-and-Actual-Parameters-Informing-Sample-Size-Calculations.pdf

Online appendix G: Programme administration costs

https://www.3ieimpact.org/sites/default/files/2019-09/TW14.1006-Online-appendix-G-Program-Administration-Costs.pdf

Online appendix H: Intervention staff training costs

https://www.3ieimpact.org/sites/default/files/2019-09/TW14.1006-Online-appendix-H-Intervention-Staff-Training-Costs.pdf

Online appendix I: Intervention implementation costs

https://www.3ieimpact.org/sites/default/files/2019-09/TW14.1006-Online-appendix-I-Intervention-Implementation-Costs.pdf

Online appendix J: Village banner for post-endline results sharing

https://www.3ieimpact.org/sites/default/files/2019-09/TW14.1006-Online-appendix-J-Village-Banner-for-Post-Endline-Results-Sharing.pdf

Online appendix K: Water and sanitation characteristics of the full study population

https://www.3ieimpact.org/sites/default/files/2019-09/TW14.1006-Online-appendix-K-Water-and-Sanitation-Characteristics-of-the-Full-Study-Population.pdf

Online appendix L: Demographic characteristics of participants in FGDs concerning perceptions and spillover of the Sundara Grama intervention

https://www.3ieimpact.org/sites/default/files/2019-09/TW14.1006-Online-appendix-L-Demographic-Characteristics-of-Participants-in-FGDs-Concerning-Perceptions-and-Spillover-of-the-Sundara-Grama-Intervention.pdf

Online appendix M: Demographic characteristics of participants in IDIs and FGDs concerning perceptions and spillover of the mothers' group activity from the Sundara Grama intervention

https://www.3ieimpact.org/sites/default/files/2019-09/TW14.1006-Online-appendix-M-Demographic-Characteristics-of-Participants.pdf

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