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Research Paper

A qualitative assessment of mothers' perceptions and behaviors in response to an intervention designed to encourage safe child feces management practices in rural Odisha, India

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ABSTRACT

Child feces are not always safely disposed of into a latrine, potentially contributing to fecal exposure in the household environment. In India, safe disposal of child feces is a relatively uncommon practice despite gains in latrine coverage. This study took place after the delivery of a behavior change intervention that also included the provision of potties and scoops. The aims of this research were to (1) describe current child feces management (CFM) practices, (2) explore perceptions and behaviors of mothers who participated in intervention activities, and (3) assess the spillover of intervention activities in neighboring villages. Twenty-four in-depth interviews and four focus group discussions were conducted across six villages, three of which received the intervention. Using thematic analysis, we explored caregivers' descriptions of the different strategies to manage their child's feces. The study found (i) women's access to and perception of the intervention informed their knowledge, attitudes, perceived risk, and behaviors related to CFM, (ii) most women positively perceived the messages of the intervention with varying use of the tools provided for feces disposal, and (iii) there was no spillover in the neighboring villages. Our findings underscore that CFM practices must be addressed to reduce fecal contamination of the environment.

Key words: behavior change, focus group discussions, in-depth interviews, mothers, open defecation, sanitation

HIGHLIGHTS

- Family roles and responsibilities often interfered with the ability of mothers to attend the intervention.
- Caregivers employed a variety of fecal management strategies dependent on the age of the child and location of defecation.
- Participants in intervention villages reported some level of use of the child feces management tools provided in the intervention, with mixed reviews on the acceptability and usefulness of these tools.

INTRODUCTION

A lack of consistent and safe management of child feces contributes to environmental contamination, enabling the risk of fecal exposure and negative health impacts, including diarrhea, environmental enteropathy, and impaired growth (Cronin *et al.* 2016; Freeman *et al.* 2016; George *et al.* 2016; Bauza *et al.* 2020; Islam *et al.* 2020). Child feces disposal (CFD) is a particular challenge in India. The most recent 2015–16 National Family Health Survey (NFHS) finds that 39% of the Indian population practices open defecation with the rural population accounting for 54% of these individuals. (Ministry of Health and Family Welfare 2017) The NFHS also reports that nationwide, safe feces disposal was only practiced for 36% with a child (<5), with the lowest rates in the state of Odisha (12.5%) (Ministry of Health and Family Welfare 2017).

Caregivers in many low-income settings dispose of their child's feces near the household compound, in fields, rivers, or bury in soil (Gil *et al.* 2004). Key reasons for unsafe disposal of child feces include the lack of understanding of the pathogenic risks of child feces, the perception of child feces as harmless, and a lack of access to diapers, potties, and/or supplies that aid safe disposal practices and limited knowledge about safe disposal practices among mothers and caregivers (Banda *et al.* 2007; Majorin *et al.* 2014; Water and Sanitation Program, World Bank Group, & United Nations International Children's Emergency Fund (UNICEF) 2015; Freeman *et al.* 2016).

Few studies have investigated caregivers' perceptions of interventions designed to improve CFD behaviors. Research in Bangladesh and Cambodia found mothers and caregivers supported the use of potties, as they saved time, were low-cost, and made the process of feces disposal easier (Miller-Petrie *et al.* 2016; Hussain *et al.* 2017). In India, research has taken place to descriptively examine child feces management (CFM) practices among households that received potties, scoops, and training (Bauza *et al.* 2020); however, caregiver perceptions and reactions to this and other interventions designed to improve safe CFM practices have not been assessed. Understanding CFM practices – which includes the use of materials/tools to pick up or catch the feces, feces disposal, cleaning of materials/tools, and anal cleansing and handwashing practices (Miller-Petrie *et al.* 2016; Majorin *et al.* 2017; Bauza *et al.* 2020) – from the perspective of caregivers can help identify barriers to adopting safe behaviors. Further, assessing perspectives and behaviors specifically among caregivers (as a participant of a safe CFD intervention) can elucidate how the intervention was received and how it may be improved – implementation insights that are particularly useful for adaptation and scaling (Haque & Freeman 2021).

The primary aims of this research were to (1) describe current CFM practices and identify internal and external motivations for those practices, (2) explore perceptions and behaviors of mothers who participated in intervention activities designed to increase safe CFD practices, and (3) assess the potential for spillover of the intervention into adjacent, nonintervention communities in rural Odisha, India. This study initially focused on the singular practice of CFD but was later expanded to the broader topic of CFM to include behaviors and norms beyond the practice of disposal alone.

METHODS

Study design and setting

This qualitative sub-study was conducted between June and July 2018 as part of a larger study that assessed the impact of an intervention – *Sundara Grama* (Beautiful Village), on latrine use and safe CFD among latrine-owning households in Puri, a coastal district of Odisha (Caruso *et al.* 2022). The larger study involved 72 total villages, with 66 engaged in a cluster-randomized trial (CRT) to assess intervention impact. This sub-study, composed of 24 in-depth interviews (IDIs) and four focus group discussions (FGDs), took place in the remaining six villages (not included in the CRT), three of which received the intervention.

The impact evaluation found a 6.4% increase in reported latrine use for individuals aged 5 and over and a 15.2% increase in reported safe CFD for individuals under age 5 in the intervention group, after accounting for observed increases in latrine use and safe disposal of child feces in the nonintervention group. The 15.2% increase is inclusive of both caregiver disposal of feces into a latrine and child latrine use (Caruso *et al.* 2022).

The intervention activity in *Sundara Grama* that addressed safe disposal was a Mothers' Group (MG) meeting, a one-time meeting open to all mothers and caregivers of children under age 5, regardless of latrine ownership. Community mobilizers from the local implementing partner, Rural Welfare Institute (RWI), facilitated meetings in each intervention village. Meetings included the following components: participant sharing of current CFM practices, health messaging on the risks of exposure to (adult and child) feces, demonstration of safe CFM practices for different child age groups (infant, toddler, and young child), distribution of scoops (dustpans) and potties to each participating household with a demonstration on how to use them for safe disposal, action planning for adopting the new safe practices, and a group pledge to always practice safe disposal of child feces (see Supplementary Information for photos of intervention materials). Results from a process evaluation of the *Sundara Grama* intervention confirmed that the MG meetings were implemented as intended, with a strong average delivery score of 81%, and were attended on average by 47% of the target households (Sclar *et al.* 2022).

Data collection

In-depth interviews (IDIs)

Twenty-four IDIs were conducted in the three villages that received the intervention to explore caregiver insights about the intervention and their CFM practices. The IDI guide included questions about caregiver's routine CFM practices, perceptions of the MG meeting, and perceptions and use (or non-use) of the potty and scoop. The guide was iteratively revised for cultural competency, appropriate language choice, and relevant subject content throughout the data collection process.

Caregivers, including mothers and grandmothers of children (<5), who attended the MG meeting were eligible to participate in the IDIs. Recruitment for the IDIs was conducted the day before interviews where *Anganwadi* (a government-run rural childcare center) worker helped identify and recruit eligible participants. Some interviewed caregivers then aided research assistants to identify additional eligible participants (i.e. snowball sampling). IDIs were held at the participant's

home or *Anganwadi* center and duration varied between 12 and 52 min. A research assistant fluent in Odia conducted the interview and took notes during the discussion.

Two interviews were accidentally completed with women who had not attended the MG meeting. While these two interviews were unintended, the reflections captured proved informative and the data were retained in the analysis with a specific note, indicating that they did not attend the MG meeting.

Focus group discussions (FGDs)

To explore general CFM practices, four FGDs with 7–14 women each were conducted in the three villages that did not receive the intervention. Two of these villages, which were directly adjacent to an intervention village, were specifically selected to explore potential spillover. The discussion guide included questions on CFM practices and awareness of and/or attendance at the MG meeting in the neighboring village. The guide also solicited perceptions of the other *Sundara Grama* intervention activities, and the findings are published elsewhere (De Shay *et al.* 2020). FGD guide development followed the iterative process the same as the IDI guide.

Because the FGDs also aimed to understand awareness and perceptions of other *Sundara Grama* activities, all participants were not required to be mothers or caregivers of children under the age of 5. *Anganwadi* workers also aided in the recruitment FGDs participants and snowball sampling was used to identify additional participants. FGDs were held at the *Anganwadi* center or village clubhouse and lasted between 18 and 33 min. One female research assistant fluent in Odia facilitated the discussion, while another research assistant took notes.

Data management and analysis

IDIs and FGDs were digitally recorded and transcribed directly into English. Debrief notes were prepared based on discussions with research assistants after each IDI and FGD was completed. All transcribed recordings, field notes, and debrief notes were analyzed using MAXQDA 12. Thematic analysis was used to examine emergent patterns and variations in participant responses. Transcripts were used as the primary data source for the analysis, while field and debrief notes were referenced for richer context. An inductive coding approach was used to maintain the integrity of the intentions and meaning of the quotes that developed each code. Key themes and sub-themes were identified in order to capture the lived experiences of the participants. A conceptual model was built from these themes to describe the social and environmental factors that influenced caregivers' CFM practices.

RESULTS

Participant characteristics

Twenty-four women participated in IDIs and 37 women participated in FGDs. Most of the IDI women (75%) were <40 years old, while the majority of FGD women (51%) were 40 years or older (Table 1). All IDI participants were Hindu and married, 75% had primary education or higher, 42% were 'other backward caste' (OBC) and 42% were general caste, 64% had more than one child, and 75% self-reported having a functional latrine. All FGD participants were Hindu, 87% were married, only 35% had primary education or higher, only 10% were OBC and 68% were general caste, 68% had more than one child, and 49% self-reported having a functional latrine.

CFM in context

Caregivers' narratives from intervention and nonintervention villages revealed how CFM practices were influenced by family roles and responsibilities, household environment and women's knowledge, attitudes, and perceived risk of CFM behaviors. Among women in villages that received the intervention, family roles and responsibilities influenced their perceptions of and access to the meeting, which, in turn, influenced their knowledge, attitudes, and perceived risk of CFM behaviors (Figure 1). In the sections below, we describe general CFM practices and motivations for those practices, focusing on behaviors prior to the intervention, followed by the findings on women's access to and perception of the MG meeting and distributed hardware (i.e. potties and scoops), and intervention spillover to nonintervention villages.

CFM practices in intervention and nonintervention villages

This section presents the typical defecation locations for children, the various strategies of caregivers employed to manage their child's feces (including cleaning the area where a child defecated and putting materials like paper or cloth under

Table 1 | Demographic information for participants in IDI ($n = 24$) and FGD ($n = 37$)[a]

	IDI participants (24)		FGD participants (37)	
Characteristics	***N***	**% or SD**	***N***	**% or SD**
Age (mean)	34.7	13.3	41.9	11.5
20–29	9	37.5	6	16.2
30–39	9	37.5	12	32.4
40–49	1	4.2	5	13.5
50–59	2	8.3	10	27.0
60–69	3	12.5	4	10.8
Education				
None	3	12.5	10	27.0
Some primary	3	12.5	12	32.4
Primary completed	5	20.8	9	24.3
Some secondary	9	37.5	3	8.1
Some tertiary/university	4	16.7	1	2.7
No formal education, but literate	0	0.0	2	5.4
Have a Below Poverty Line (BPL) card				
Yes	19	79.2	31	83.8
No	5	20.8	6	16.2
Marital status				
Single	0	0.0	1	2.7
Married	24	100	32	86.5
Widowed	0	0.0	4	10.8
Years married				
0–5	2	8.3	1	2.7
6–10	3	12.5	1	2.7
11–15	1	4.2	3	8.1
21–25	0	0.0	4	10.8
26–30	0	0.0	4	10.8
31–40	0	0.0	2	5.4
No response	18	75.0	22	59.5
Hindu	24	100	37	100
Caste				
General caste	10	41.7	25	67.6
Scheduled caste (SC)	4	16.7	2	5.4
OBC	10	41.7	10	27.0
Number of children (mean)	1.8	0.7	2.1	0.8
0	0	0.0	2	5.6
1	10	41.7	9	25.0
2	10	58.3	18	50.0
3	4	16.7	6	16.7
4	0	0.0	1	2.8
Youngest child age in years (mean)	3.4	3.2	11.2	8.5
< 1	3	12.5	2[b]	2.9

(*Continued.*)

Table 1 | Continued

Characteristics	IDI participants (24)		FGD participants (37)	
	N	% or SD	*N*	% or SD
1	3	12.5	1[b]	1.4
2	3	12.5	3[b]	4.3
3	10	41.7	2[b]	2.9
4	4	16.7	5[b]	7.1
5	0	0.0	0[b]	0.0
> 5	1	4.2	21[b]	61.8
Youngest child sex				
Female	8	38.1	12[b]	35.3
Male	16	61.9	22[b]	64.7
Functional latrine in household compound				
Yes	18	75.0	18	48.6
No	1	4.2	19	51.4
No response	5	20.8	0	0.0
Caregiver's use of latrine for defecation				
Always	10	41.7	18	48.6
Sometimes	1	4.2	0	0
Never	10	41.7	0	0
No response	3	12.5	19	51.4

[a]We use the caste designations of the government of India for consistency (Ministry of Social Justice and Empowerment 2018).
[b]$N = 34$ as two women did not have children and one did not provide a response.

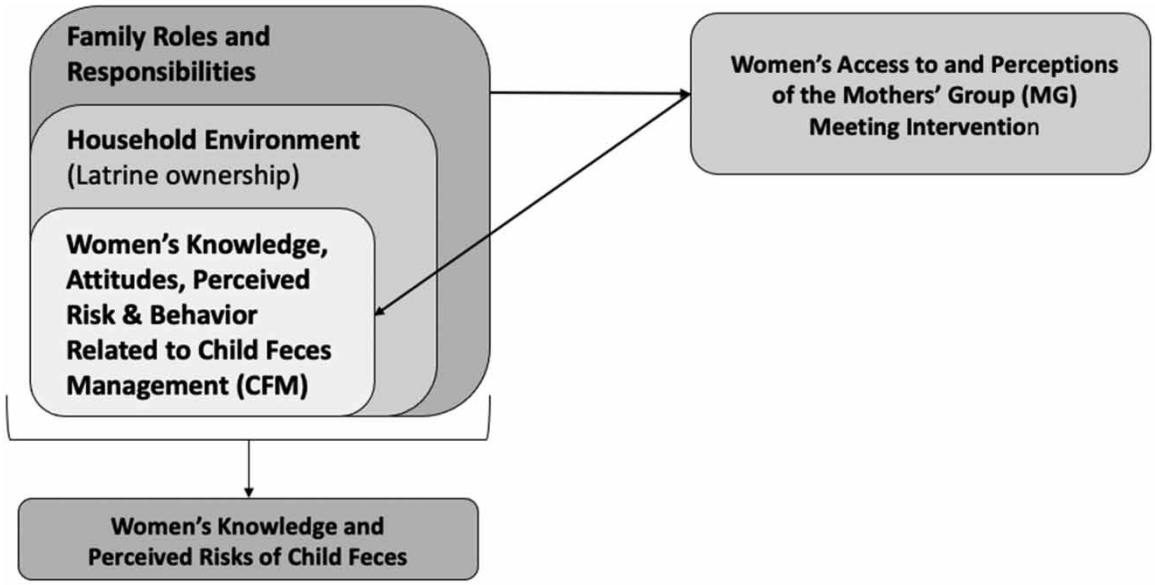

Figure 1 | A conceptual model for how societal and environmental factors inform women's CFM practices and perceptions of and access to the MG.

their child's bottom prior to defecation), managing those materials, and cleaning their child's and their own hands after a defecation event.

Children's defecation locations were different and often depended on the child's age. Caregivers described babies and young toddlers defecating in and/or around the household, while older toddlers defecated in a variety of locations: in

and/or around the household, in the open away from the household compound, or defecated in the latrine. For children aged 3 and above (in nonintervention villages), defecation in the open fields was the most common practice. Among the caregivers (of intervention villages), 12 (50%) described that at least one of their children between the ages of 3–5 years used the latrine. Ten (83%) of these caregivers specifically stated that their child used the latrine regularly, with the majority of these children being 3 or 4 years old.

To clean the defecation site, caregivers followed different methods depending on the location. If the defecation occurred on a concrete floor, spraying the site with water and cleaning with a broom was done. If it was on soil, some described using a mixture of water, cow dung, and straw to clean. If it was in the home, first cleaning with water, and then spraying of 'phenyl' (disinfectant) and 'Dettol' (disinfectant brand) were practiced.

Participants described that it was common for children to defecate in the home on a cloth, paper, or in a diaper that they then had to manage. Women with and without a latrine described throwing the soiled paper or soiled cloth outside the home into a waste pile, compost pile, or dustbin. In some cases, when a cloth was used to collect feces, it was subsequently washed sometimes in a river (where water from the same source was collected for cooking) and then hung outside to dry. Mothers explained that 'Huggies' (diaper brand) was often used when a child had diarrhea or at night and was then thrown into the waste pile or compost pit.

With regard to hygiene practices, some mothers described taking their child to the tube well or to a river for anal cleansing and washing after defecation. The water from the tube well either flowed into a drain and then into an open field, or, in the absence of a drain, it soaked into the soil. A few participants described cleaning their own hands afterward because they were the ones more actively engaged in the cleaning of feces.

Family roles and responsibilities related to CFM

Based on caregivers' narratives, family roles and responsibilities influenced CFM practices. In both intervention and nonintervention villages, caregivers of children under 5 gave similar descriptions of what it meant to be the child's primary caregiver: responsibilities included feces disposal, feeding, bathing, and escorting children to school and/or to the school bus. Another key role of caregivers was keeping their child clean. They believed that if they kept the child clean, the child could not fall sick from any kind of infection caused by feces. Keeping children clean and feces disposal, both components of CFM, are perceived as one of the main responsibilities of mothers/female caregivers.

Household environment related to CFM

Toilet access, a critical component of the household environment, influenced the specific CFM practice of disposal. Caregivers who did not have access to a toilet were physically unable to safely dispose of their child's feces, while caregivers with access had the environment to enable safe disposal. In intervention villages, 75% ($n = 18$) of participants had access to a functional household toilet, while 51% ($n = 19$) of participants from the nonintervention villages did not. It was typical for most latrine-owning households to have a pour-flush latrine, where the user brings their own water to flush. (For more on latrine construction, see Figure S3 in the Supplementary Information).

Knowledge and perceived risk of child feces

Along with family roles and responsibilities and the household environment, women's CFM practices were also influenced by their personal knowledge and perceived risk of child feces. Most participants in both intervention and nonintervention villages perceived child feces to be a potential health risk. They perceived child feces contained germs, and other germs could grow on them if were left in the open. Others described the odor of child feces as disgusting, dirty, or filthy, especially when children were sick or if feces were left in the open. Participants described flies as a potential health risk as they sit on feces and then come in contact with food and utensils in the household, bringing germs and subsequently diseases. A few caregivers threw their child's feces far away from their home but noted that the feces still posed a health risk because flies would still be able to come in contact with the feces thrown far away. However, some disagreed, stating that if feces were thrown far enough away from the home they could no longer pose a health risk.

Overall caregivers reported 'loose motions' (i.e. diarrhea), vomiting, and fever as common health issues their children experienced. However, caregivers rarely said that an ailment *their* child had experienced was due to exposure to child feces. While in the minority, caregivers did not consider child feces to pose a health risk and held a perception that the child's diet was protective.

Caregivers' access to and perceptions of the MG meeting

As shown in the conceptual model, family roles and responsibilities constrained the caregivers' access and participation in the MG meeting and subsequently impacted their perception of the MG meeting for mothers. Attendance at and perception of the meeting, in turn, influenced their knowledge and perceived risks of child feces, which subsequently influenced their CFM behaviors.

Caregivers' access to the MG meeting and other intervention activities

The MG meeting could not be accessible/attended by all eligible women in the intervention villages, as they were excessively overloaded with other family priorities like the household's day-to-day chores, their management, and above all the childcare-related obligations. Culturally, it was not acceptable for women, especially young mothers, to be seen in public spaces or share spaces with elder brothers-in-law in the village, for which some caregivers could attend only the MG meeting and no other intervention activity. This was also a reason that the MG meeting and other intervention activities were attended or represented by the elder women of the family – typically the mothers-in-law instead of the mothers of children under the age of 5 in.their household. It was found that only a few mothers-in-law attending MG meetings conveyed the information/messages to their daughters-in-law once they returned home.

The role mothers played as primary caregivers for children impacted their experience at the MG meeting or constrained their attending other intervention activities. Two mothers stated that their child crying or being 'naughty' at the MG meeting sometimes caused others to suggest that they go home or pressured them to independently choose to go home or stand outside the meeting room to listen from afar. Some mentioned that the timing of the other intervention activities conflicted with household chores including their children's meal-time and family worship time (*pooja*). Few mentioned that the meeting venue was too far away from their home to travel and attend with a child.

Caregivers' perceptions of messages from the MG meeting

Most caregivers who attended the MG meeting had positive perceptions of how the messages were delivered. Repetitive presentation of information/messages, use of pictures to illustrate examples of behaviors and potential barriers to safe disposal, and provision of instructions in Odia were particularly useful. The majority perceived the MG meeting to be valuable as it provided new information, such as guidance on how to clean children after defecation, clean disposal tools after use, dig pits for disposal of feces in the absence of a latrine at home, and also taught about the health risks related to adult and child feces.

However, some did not perceive the MG meeting as a source of new information. Some older women mentioned having prior knowledge about these safe practices from their older children who traveled outside the village, while others indicated that they already had access to disposal tools (potties, scoops, and 'Huggies'), or knew how to clean their children and their clothing.

Caregivers' CFM practices post-intervention

Among women who received hardware as part of the intervention, varying use of the tools for feces disposal was described. For women who did use the tools for any length of time, there was variation in the consistency of safe usage.

Usage and perception of the scoop

Only three mothers (13%) reported some type of use of the scoop. The scoop was envisioned for use with small children, like those under the age of 2, but one woman described using both the latrine and the scoop with her 3-year-old child. Despite low usage, perceptions and opinions about the use of the scoop for feces disposal were positive. Mothers cited that it provided a more hygienic option for disposal because it enabled no fecal contact with their hands, was useful for cleaning when a child had defecated in the open without notifying the mother beforehand, and was useful for older children who could defecate directly into the scoop making it easier to dispose of the feces.

Usage and perception of the potty

The majority of participants reported some level of use of the potty ($N = 14$, 58%). Of them, four reported their child using the potty and the latrine. For caregivers whose children primarily used the latrine, some explained that the potty inside the home was used as an alternative if the weather was cold outside or during the night.

Among all caregivers whose children used the potty, there was variation in their management steps and a lack of clarity in their processes. A few of them mentioned dumping the feces directly from the potty into the latrine pan, rinsing the potty with water, and then sprinkling 'phenyl' before setting the potty in the sun to dry. Some used a designated brush they kept in the latrine for cleaning the potty. Two mothers without latrines described disposing of the feces in outdoor waste piles after their child defecated in the potty or scoop and washing the disposal tools in river water, which they also used for cooking purposes. For the majority of mothers, however, there was a lack of clarity on the method and consistency with which the potty and children were cleaned and feces were disposed after defecation.

Overall, caregivers expressed happiness for receiving the potty at the end of the MG meeting but gave mixed reviews on their child's acceptance of the potty and its usefulness in their daily lives. Among positive remarks about the potty, caregivers appreciated that the potty was well-designed for younger children to sit on and that it was convenient; they could cover the feces in the potty and clean it later. Caregivers also mentioned that children used the potty as a toy. In some instances, this was a positive attribute; one mother described how the potty was helpful to both entertain her child and provide somewhere for him to defecate since her household did not have a latrine. However, in other cases, children would not defecate in the potty precisely because they considered it a toy and they did not want to dirty it.

Caregivers who were still training their children to use the potty or were not using the potty also described deterrents to use, including child's age, a fear of damaging the potty, and disgust, as well as issues with the potty itself. Some viewed that the height of the potty was too low for older children (>3 years) to use, thus making the squatting position uncomfortable for defecation. One of the mothers described that she was considering setting the potty on bricks to make it at a height, thus enabling the child to comfortably squat. A few described difficulty using the potty with younger children because the child could not sit on the potty without being held. Mothers also frequently mentioned a fear that their child would break the potty, and one mother indicated that her children had already broken the potty. Others noted that siblings would fight over the potty. To avoid breaking or fighting over the potty, mothers hid or hung it out of reach. Another mother reported that her child was disgusted to use the potty because of the bad smell of defecating in the same location consistently, preventing use.

Three caregivers of varying potty uptake shared an innovative potty usage technique that was not taught in the MG meeting. All three mothers described lining the potty with paper for the child to defecate on and then disposing of the paper. The reasons cited were because it made it easier for them to clean the potty, as feces did not stick to the potty.

Prior to having the potty, caregivers shared that they knew the signs or signals when a child needed to defecate. Either the child explicitly said or they could gauge from their child's facial expressions. After receiving the intervention, some caregivers reported that their child specifically would ask for the potty when they needed to defecate whereas in some cases, the child would decide whether or not to use the potty or latrine depending on their mood. In one case, a child explained to their mother that they would not use the potty because other people were not using it for defecation. In such situations, the mother did not further pressurize or encourage the child to use the potty.

Caregivers also shared their varying perceptions of the time and effort needed for training the child to use the potty. Only two mothers believed it would take time to train and instill this new behavior in their child. A few mothers indicated that no extensive training was needed as their children responded well to the potty and were able to use it without discomfort.

Perceptions of intervention spillover in nonintervention villages

In the nonintervention villages, none of the caregivers had heard about the MG meeting or distribution of the potty and scoop to attendee caregivers. Some women described hearing about the overall intervention program through telephone calls from residents of the intervention villages or claimed to have heard about it on television but could not provide any further details about the activities conducted.

DISCUSSION

We conducted a qualitative study to assess CFM practices in rural Odisha and to understand caregiver perceptions of an intervention designed to increase the safe disposal of child feces. Findings revealed how CFM practices were influenced by other roles and responsibilities within the family, the household environment, and women's knowledge and perceptions of risk, which is consistent with socio-ecological models that understand health behaviors to be influenced at multiple levels.

Consistent with previous research, our findings demonstrate that mothers are largely responsible for the management of child feces (Banda *et al.* 2007; Miller-Petrie *et al.* 2016; Majorin *et al.* 2019; Bauza *et al.* 2020), yet their roles and responsibilities within the household posed barriers to attend the intervention activities like the MG meetings. A mixed-method study

in rural Odisha found that women have also faced barriers to attending and participating in village-wide sanitation awareness meetings, particularly younger newly-wed women (Routray *et al.* 2017). Our findings, also in rural Odisha, further support Routray's findings as we also found that younger mothers were not permitted to attend the women-only MG meeting. These findings together highlight the need for programs, especially those targeting young mothers, to consider the broader social dynamics that exist within the household and community environments. Engaging female gatekeepers, such as grandmothers and mothers-in-law, as was done in Senegal as part of the Grandmother Project ('Grandmother Project' n.d.), or one-on-one interactions with young women may be more effective modes of engagement.

The Diffusion of Innovation Theory, which identifies five specific characteristics that facilitate the rapid diffusion of ideas (high relative advantage, triability, observability, compatibility, and low complexity), can be used to understand our findings related to intervention engagement and adoption (Rogers 1962). Specifically, our data suggest that compatibility with family structure and roles are a major deterrent to household adoption of CFM behavior changes. Within this context, individual beliefs about the risks of feces minimize the potential perceived advantages of the intervention. Trialability, observability, and low complexity appear to be assets of the sanitation intervention. However, the novelty of the potty seems to be an initial barrier that may disappear over time as it becomes familiar with the environment.

Diffusion of Innovation also looks at the characteristics of those individuals who are more or less likely to adopt a new idea to explain how, over time, an idea gains momentum and diffuses through a social system. There are five adopter categories: Innovators, Early Adopters, Early Majority, Late Majority, and Laggards (Rogers 1962). Our data suggest that the women we interviewed are in the Innovator or Early Adopter category in their CFM practices. Women at the Innovator level were those willing to take the risk to first use the hardware and adapt the hardware to meet the needs of their children. To the extent that these innovators are influential and well regarded, the more likely it is they will inspire replication. We also found that women within the Early Adopter category were willing to try our intervention and the hardware. They adopted the new ideas but still needed to see further evidence that the innovation could be successful before fully implementing. For example, after attending the MG activity, over half of the participants reported use of the hardware with their child, but it was rare that a mother or caregiver practiced safe fecal management through all steps of CFM. A cross-sectional, mixed-methods study that took place in the same six study villages a few months later further confirmed these qualitative findings and provides additional insights (Bauza *et al.* 2020). Specifically, the use of the potties and scoops remained mixed in these communities, though benefits were noted among those who did use them (Bauza *et al.* 2020). Notably, the use of the potty and scoop for moving feces did not increase caregiver *Escherichia coli* hand contamination, whereas the use of other materials like paper, plastic bags, or straw did (Bauza *et al.* 2020). Overall, the authors conclude that intervention strategies need strengthening and should be more inclusive of the suite of CFM behaviors beyond disposal (Bauza *et al.* 2020).

CFM is a time-consuming process at every stage and is a particular burden for female caregivers who bear the responsibility. Both the potty and scoop required cleaning techniques in order to be used safely. For most mothers, the washing and drying of the potty was possible, but they needed additional time and labor for feces disposal processes, as opposed to tossing a cloth or paper in a waste pile. Innovators were creative in their adaptation of the CFM practices, making the process of using the tool easier by using papers on the potty for easier disposal. This signals the need for future intervention strategies to be less burdensome for female caregivers. Those who innovated saved time and labor, enabling them to continue with safer practices. As is noted in a recent commentary by Evans, the indirect effects of interventions on mothers or other family members may be acknowledged, but they are not quantified to understand explicit impacts, therefore potentially causing burden and exacerbating inequalities without any specific gains or benefits to the women engaged in the interventions (Evans *et al.* 2021). Therefore, interventions focused on reducing environmental contamination from child feces need to employ and evaluate strategies that reduce the burden on the female caregivers charged with taking on CFM behaviors.

In summary, strategies to escalate the rapid diffusion of CFM practices, and the use of specific hardware, in particular, will need to be intentionally developed to improve broader adoption of the MG meeting intervention and the potties and scoops. Identifying the right people in the village to champion interventions as well as those 'first followers' of the Innovators are essential to the spread and sustainability of the promoted CFM practices over time. This includes reaching women who are not able to access the intervention or use the hardware, and creating the conditions by which the CFM practices become accessible and modifiable, like women taking the initiative to use paper to line potties to save time.

Limitations

While we sought to apply a rigorous approach, there were some limitations that may have affected the data. The length of the IDIs and the FGDs were shorter than expected. This was because women were preoccupied with household chores in the daytime, for which they could not afford to stay longer for interviews. With FGDs, participants failed to respond to questions on intervention, as they had not heard anything. We iterated upon the interview tool to ask more diverse questions in later FGDs. Still, the information gathered was rich and enabled an understanding of CFM in these communities. Additionally, not all FGD participants were mothers/caregivers of children <5. However, it was likely that they did have experience though caring for children in that age group, whether their own at one point, another relative (sibling, cousin), or the child of a friend or family member, enabling them to engage in the general conversation about CFM. Finally, when data collection was conducted, the intervention villages had very recently received the intervention, some less than a week prior. Analysis of the results must be an understanding of participant's application of the lessons learned based on the short follow-up period, single-training session implemented as part of the intervention, and the novelty of the tools that may pose a challenge when seeking a change in behavior. Future interventions may consider having more opportunities for participant engagement over time.

CONCLUSION

CFM must be addressed to reduce fecal contamination of the environment. This research contributes to growing work that emphasizes the roles and responsibilities of women in sanitation interventions. Our research found that targeting young mothers in rural Odisha was a challenge, and alternative message delivery may be more effective. These findings also illuminate how safe disposal tools may need to be reassessed based on the age and cultural preference of children, and on the advantages and disadvantages, like the time burden of female caregivers, of adopting tools and practices. Future sanitation research should work to emphasize the connection between the caregiver and the child and be innovative in procuring the voices of women in designing and implementing hardware for comprehensive CFM.

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AUTHOR CONTRIBUTIONS

R.N.W. and B.A.C. conceived the original idea. R.N.W. collected the data, analyzed the data, and wrote the initial draft of the manuscript. P.R. and G.D.S. contributed substantially to tool preparation. B.A.C. and F.M. contributed substantially to research design and tool preparation. L.B. contributed substantially to research design and theory development. R.N.W. carried out the research. R.N.W. led data analysis. R.N.W. wrote the paper with significant contributions, critical feedback, editing, and supervision from G.D.S., P.R., F.M., L.B., and B.A.C.

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COMPETING INTERESTS

None declared.

ETHICS APPROVAL

Study protocols were reviewed and approved by the Institutional Review Board at Emory University in Atlanta Georgia (00098293) and the Ethics Review Committee at the Xavier Institute of Management in Bhubaneswar, Odisha, India (REF: 131216). Participants provided verbal consent prior to participation.

DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

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