Development of A Multi-dimensional Scale to Assess Attitudinal Determinants of Sanitation Uptake and Use

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ABSTRACT

Over 1 billion people still practice open defecation. Low uptake and use of new sanitation technologies in a number of settings has underscored our current limited understanding of the complex attitudinal factors that influence a household's decision to adopt and use new sanitation technologies. Mokken scaling techniques were applied to series of population-based surveys in Odisha. India between September 2011 and October 2013 (sample sizes 120, 500, 2200). Surveys contained simple, agree/disagree statements about attitudes towards sanitation use and sanitation technologies. Analysis produced two scales – a 10-question General *Scale*, reflecting attitudes towards defecation and norms regarding latrine use for all respondents, and a 6-question *Experiential Scale*, reflecting personal experiences with and perceived convenience of sanitation technologies targeted at respondents with a latrine. Among all respondents, a one-point change in the General Scale was associated with a 5-percentage point change in the marginal probability of having access to a functioning latrine. Among respondents with a functional latrine at home, a one-point increase in the General and Experiential Scales were associated with a 4- and 8-percentage point decrease in the probability of engaging in any open defecation in the last seven days, respectively.

INTRODUCTION

Access to sanitation is critical for maternal and newborn health,¹ and evidence suggests links between lack of sanitation and child undernutrition,^{2, 3} soil-transmitted helminth infection ⁴, trachoma infection ⁵, overall burden of disease ⁶, and diarrheal disease ⁷, though rigorous data is limited. Lack of sanitation is particularly challenging for women ⁸, and can lead to poor mental health and poor attendance of girls at school ⁹. India alone accounts for almost one-third of the 2.4 billion people that do not have access to an improved sanitation facility in their home; over 600 million people have no facility at all and open defecation rather than inside of a dedicated facility (irrespective of quality of facility) is likely much higher ¹⁰.

Recently, two large randomized trials assessing the impact of the government of India's Total Sanitation Campaign (TSC) found no impact on diarrheal disease, child growth, or helminth infection ^{11, 12}. Limited health impact of these interventions may be attributable to low intervention compliance – low rates of latrine uptake (new construction) and low rates of consistent use of new facilities ¹¹⁻¹³. Without proper and consistent use, environmental health interventions, such as sanitation, are unlikely to achieve health gains ^{14, 15}.

The low uptake and use of sanitation facilities underscore the critical shortcoming in both our understanding of the multiple determinants of sanitation adoption and the programmatic strategies that can most effectively target these determinants. Evidence has shown that economic barriers to latrine uptake are real and that the provision of household subsidies for construction of new facilities can increase uptake ¹⁶. Stated preference for open defecation in rural northern India – even among individuals with access to a latrine - was attributed to perceived convenience, comfort, and pleasure of open defecation and a lack of recognition of the health benefits of consistent latrine use ¹³. Attitudes towards latrines and open defecation had a statistically significant relationship with reported latrine usage in eastern India²⁰. Ethnographic studies in central India ¹⁷ found that successful adoption required political will at multiple levels, proximate social pressures (direct interaction with toilets and/or toilet users), and political ecology (policies and practices regarding environmental management) supported by state investment.

The studies by Coffey et al.¹³ and O'Reilly and Louis¹⁵ demonstrate the two primary approaches in the extant literature to understanding behavioral determinants. Coffey et al. coded responses to single open-ended questions, an approach that risks information loss by oversimplifying complex psychological or social processes. O'Reilly and Louis utilized qualitative and ethnographic research methods, methods which are ideally suited for exploring complex interactions between multiple determinants but ill suited for measuring or quantifying the impact of these determinants on specific behavioral outcomes. Scale development approaches provide a way to understand and quantify the multiple influences of behavioral determinants on sanitation adoption. Identifying and measuring the latent psychosocial and attitudinal factors that influence behaviors can inform programmatic activities through targeted behavior change communication as well as provide quantifiable intermediate outcomes that can be incorporated into program monitoring and evaluation. Mokken scaling, based on Item Response Theory ¹⁸, provides a potentially useful tool for scale development in low- and middle-income countries. Unlike factor analytic methods, Mokken scaling procedures are particularly well suited for binary response patterns, allowing for the use of simple yes/no questions or agree/disagree statements that can be easily included in orally administered surveys.

The purpose of this study was to identify and measure the determinants of uptake and use of sanitation facilities in rural Odisha, India. A secondary objective was to develop and validate a psychometrically robust scale of attitudes towards latrine uptake and use based on a parsimonious set of survey questions for use in future research. The study was conducted in the context of a cluster randomized trial¹⁹ assessing the impact of sanitation interventions on child health outcomes.

STUDY OVERVIEW

This study took place in Odisha, India, as part of a 3-year cluster randomized trial conducted in 100 villages ¹⁹. The trial evaluated the impact of the TSC, a government-supported program implemented by local NGOs with support from WaterAid, a UK-based non-governmental organization. Latrine access in the study site was 8% prior to the intervention, but increased to 37% in intervention villages one year following the start of the intervention ²⁰ with consistent use assumed to be even lower ²¹.

ETHICAL APPROVAL

Ethical approval for the study was provided by the London School of Hygiene and Tropical Medicine (London, UK) and the Xavier University (Odisha, India). Prior to enrolment, field workers fluent in Oriya read an information sheet describing the study, answered any questions and asked for written consent to participate. The study participants received no compensation for their participation. Anonymity was ensured through the use of household identification numbers and no names were recorded.

DATA COLLECTION AND ANALYSIS

Trained enumerators collected data through orally administered survey instruments. Enumerators also received specific training in the elicitation of agree/disagree responses led by investigators familiar with survey methods and fluent in the local language. Data collection and analysis occurred in three discrete phases – determinant identification, scale development, and scale validation – with the result of each phase informing methods and scope of subsequent phases. All data were analyzed in Stata 13 (College Station, TX). Because of this interdependent process, we present methods and results associated with each phase of research in chronological order with a summary discussion.

PHASE 1: DETERMINANT IDENTIFICATION

METHODS

Preliminary research that informed the identification of specific behavioral determinants included pilot surveys used in the development and validation of a new household sanitation behavior scale (the Safe San Index) to measure safe and consistent sanitation usage in India ²². In 2011, seven focus group discussions with latrine owners and one with TSC field workers were completed ²³. These discussions focused on attitudes towards latrine use, views on latrine technologies implemented as part of the TSC campaign, and continued open defecation practices and attitudes. Data were collected and transcribed in Oriya and translated into English. Further details on these focus group discussions are provided in Routray et al ²³

From English language transcripts, a series of 47 statements reflecting respondents' views on sanitation practices and latrine use were developed and included in an exploratory survey of 120 households (for details see Jenkins et al. ²⁰). Statements were read to survey participants and respondents were asked to agree or disagree with the statement. Respondents were also given the opportunity to not answer the question if they did not know the answer or if the question was not applicable.

A panel of three Indian and four International sanitation behavior experts reviewed each statement prior to analysis to determine if the statement expressed a positive or negative view towards sanitation adoption and use. Data were coded so that the positive view towards sanitation was associated with a value of 1. All other values – negative values, non-answers, and "don't know" – were assigned a value of 0. Prior to analysis, questions with insufficient variability (> 90% of respondents in a single category) were discarded from further analysis. The pre-specified steps were to ensure both sufficient variability in the response patterns and an adequate sample size for our exploratory analysis. Mokken scaling procedures – a forward selection procedure utilizing the *msp* command in Stata - were applied to all remaining questions. Questions were analyzed without *a priori* assumptions about their relationships, ensuring that factors identified through analysis were reflective of respondents' answers and not based on theoretical or behavioral frameworks. Because this analysis was exploratory and based on a limited sample, no additional analyses or modifications to the results were pursued. Rather, the study team

reviewed question groupings identified through the msp procedure and definitions defined based on content and wording of the identified questions.

RESULTS

Of the 47 questions included in the initial 120-person survey, 14 were dropped for lack of variability in responses. Mokken scaling procedures applied to the remaining 33 questions identified 5 emergent determinants related to sanitation use and adoption. A group of questions emerged related to attitudes towards open defecation, including questions such as "Open defecation is part of my every day activities" and "I enjoy the freedom of going for open defecation." A second group of questions clustered around norms and social expectations regarding sanitation, including questions such as "Most of my friends and relatives use the latrine every time they defecate" and "Most of the men in my village are regular users of the latrine." These two determinants were independent of an individual's own latrine use or ownership, and reflected attitudes towards sanitation and latrine use in a broader sense.

A second set of determinants was identified that related to use and experiences with a specific sanitation technology in the home. These included self-assessments of attributes and characteristics of the household latrine, including questions such as "the pit is small and would fill too quickly if everyone used the latrine every day" and "we chose the design for this latrine after considering different styles." Another set of questions emerged that related to an individual's perceptions of the convenience of using a household latrine, including: "Regular use of the latrine for defecation would restrict me to the house all day" and "It is more convenient in the morning to use the latrine because of my busy schedule." A final group of questions were identified that related to sharing the sanitation facility in the home, including "There are too many people in the household for just one latrine" and "In the morning if the latrine is in use by another member, I go for open defecation."

PHASE 2: SCALE DEVELOPMENT

METHODS

Determinants identified in Phase 1 formed the basis of subsequent data collection activities. The original 33 questions included in Phase 1 analyses were expanded and adapted based on original focus group transcripts, preliminary survey instruments, and additional survey questions available to the study team. Questions were reviewed by members of the study team and assessed against theoretical and behavioral models both general ²⁴⁻²⁹ and specific to water and sanitation ³⁰⁻³². We divided the determinant related to norms into two: descriptive norms (the extent to which individuals perceive others in their community to use a latrine) and

injunctive norms (the extent to which individuals perceive others in their community expect them to have and use a latrine at home) ^{33, 34}.

This expanded set of questions was organized into a second survey instrument consisting of 42 agree/disagree questions that collected data on a total of six pre-specified determinants organized into two main groups. General determinants reflected generalized attitudes towards latrines and defecation practices and included: 1) attitudes towards open defecation (9 questions), 2) descriptive norms (5 questions), and 3) injunctive norms (7 questions). The second group consisted of factors reflecting individual experiences or preferences towards existing sanitation infrastructure and included: 1) attitudes towards specific latrine technologies (8 questions), 2) access and sharing of sanitation facilities (4 questions), and 3) convenience of using a latrine (7 questions). We refer to these as *experiential determinants* given their reliance on direct interaction with a latrine in the home. In addition to these emergent determinants, two questions were included on individual perceptions about the community-level health benefit of sanitation.

This second survey was administered to one respondent in households with (n=200) and without a latrine (n=300) in March and April of 2013. Questions related to the *general determinants* and questions on community-level health benefits were asked of all respondents. Questions related to *experiential determinants* were asked only to respondents with a latrine at home.

The purpose of Phase 2 analysis was to identify a parsimonious set of 3-5questions that captured the diversity of response patterns within each determinant while maximizing their potential utility as scales. Binary response questions were again coded so that a positive response was associated with a positive view towards sanitation. In contrast to Phase 1, questions were analyzed according to the predefined determinants. For example, all questions pertaining to *descriptive norms* were analyzed together and independent of questions prescribed to other determinants, all questions related to attitudes towards open defecation were analyzed independently, etc. Analysis was an iterative process between the application of the automated forward selection statistical procedure in Stata and a backwards selection process based on question specific Loevinger H coefficients (the ratio of observed errors from a "perfect" response profile over the expected number of errors from this same profile due to chance alone), question-specific difficulty, and potential redundancies in the content and nature of the question. Details on the analysis and the parameters incorporated into the decision making process are described in the Supplemental Materials (S2: Scale Development Process)

RESULTS

A table of all questions included in this analysis and the specific reasons questions were discarded from each determinant is included in S2.

Among the *general determinants* pool of 9 questions associated with attitudes towards open defection, analysis suggested 2 different determinants: 1) attitudes towards open defecation (5 questions) and 2) attitudes towards feces and fecal management (2 questions). Four questions out of the pool of 5 related to descriptive norms were retained. For injunctive norms, none of the 7 questions met initial inclusion criteria, and so the 2 questions with the strongest relationship were chosen. For experiential determinants, 4 out of 8 questions related to latrine attributes were retained; and 4 out of 7 questions related to latrine convenience were retained. For attitudes towards shared sanitation, no set of questions collectively met inclusion criteria and so 2 questions were selected for further data collection. The 2 questions related to community-level health benefits from sanitation were discarded from the analysis at this point due to insufficient variation – over 98% of respondents answered in the affirmative to each of these questions.

The final result of this phase of analysis was a set of 23 agree/disagree questions divided into two groups. The *general questions* included 13 related to attitudes towards latrines and defecation practices of the individual and the community; the *experiential questions* included 10 related to direct experiences with the use and operation of sanitation facilities in the home.

PHASE 3: SCALE VALIDATION

METHODS

The final set of 23 general and experiential questions were included in routine data collection in October 2013 for 2,202 households in 100 villages (50 intervention and 50 control). See Clasen et. al. ¹¹ for further details on data collection.

Respondents reported on access to and state of the household's sanitation infrastructure. Use was assessed by self-reported open-defecation practices (see below). The *general questions* were administered to all households; the *experiential questions* administered in those households with a latrine. Data were recorded on paper surveys and entered using EpiData 3.1 (EpiData Association, Odense, Denmark). Quantitative data was analyzed in Stata v.13 (College Station, Texas).

In order to combine general questions and experiential questions into specific scores, we reapplied Mokken scaling techniques to question groups associated with specific determinants. We discarded measurements of specific determinants if no combination of questions could be identified that had a combined Loevinger H greater than 0.5. Within the group of questions associated with specific determinants meeting this criteria, we retained questions with Loevinger H values between 0.4 and 0.5 provided their inclusion did not lower the Loevinger H for the combined set of items below 0.5. Retained items were converted to scales by summing the total number of pro-sanitation responses. Two scales were calculated

- the *General Scale* as the sum of all retained general questions and the *Experiential Scale* as the sum of all retained experiential questions.

We compared calculated General and Experiential Scale scores against two predetermined behavioral outcomes: latrine uptake and self-reported consistent latrine use. We defined *uptake* as self-reported access to a toilet or latrine facility that was working properly (waste flushing correctly) and where the respondent considered the facility's roof and pan "complete." For consistent *use*, we defined a binary indicator of self-reported open defecation by the respondent in the seven days prior to data collection. We defined this variable based on three questions included in the Safe San Index ²²: 1) On how many of the mornings of last 7 days did <u>you</u> defecate in the open (e.g., field, roadside)?; 2) On how many evenings of last 7 days did <u>you</u> defecate in the open at noon time or at night? All questions had four prescribed response choices: every day, most days, some days, no days. If a respondent provided any answer other than "no days" to <u>any</u> of the three questions, they were coded as engaging in open defecation.

Scale values were assessed against binary behavioral outcomes using logistic regression models with the following equation:

$$log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_0 + \beta x_{ij} + \ldots + u_{0j}$$

Where π represents the outcome of interest and u is the community-specific random intercept, included to control for community clustering. In order to account for the range of interventions activities that may impact behavioral outcomes, all models included as a covariate (x) a binary dummy variable indicating if the household was located in a community that was part of the TSC program or not. For latrine uptake, covariates were General Scale score as a continuous predictor variable and the binary intervention dummy variable. Exploratory analysis found evidence of an interaction between the General Scale and intervention status, so final models included a covariate related to the interaction between the two. For consistent use, covariates were the General Scale score and Experiential Scale score as continuous predictors and the intervention dummy variable. No interaction terms were included in models related to use.

Regression coefficients were translated into average marginal effects – the average change in the probability of the outcome of interest (latrine ownership or consistent latrine use) for every one-unit change in the covariate of interest (i.e., Generalized Scale, Experiential Scale, intervention status) when all other covariates are held constant at existing individual values – and predicted marginal probabilities calculated at all possible values of scales in order to assess linear trends between scale scores and behavioral outcomes.

RESULTS

For *general determinants*, one question related to attitudes towards open defecation was discarded because of Loevinger H < 0.5. Questions related to injunctive norms did not meet final inclusion criteria. This left a final set of 10 General Scale questions reflecting attitudes towards open defecation (4 questions), attitudes towards fecal management (2 questions), and descriptive norms (4 questions). (Table 1) Questions retained for each determinant demonstrated non-intersecting double monotonicity, or simply stated: each question provided unique information that differentiated between respondents with similar overall General Scale scores.

Question difficulty (the proportion of people who answered in the negative) was not considered in this final stage of the analysis. Full data for the calculation of the General Scale was available from 2,202 individuals. Calculated scores ranged from 0 to 10, with a mean score of 4.7 (SD: 2.4) (Figure 1). Cronbach's alpha for the General Scale was 0.701, suggesting good internal consistency of items, although we note that the combined scale included three distinct determinants.

Data on experiential determinants were only available from respondents with any latrine at home. For each of the 4 questions tested to assess attitudes towards latrine attributes and 4 tested to assess latrine convenience, 1 question from each did not meet inclusion criteria, nor did the two questions tested as a measurement of shared sanitation access. The Experiential Scale, therefore, reflected the summed value of six agree/disagree questions – three related to latrine attributes and three related to the perceived convenience of using the household's latrine. Questions related to each determinant also demonstrated double monotonicity.

Full data for the Experiential Scale was available from 920 individuals. The sample size for this scale was lower, as questions were only asked to respondents that self-reported access to a sanitation facility at home. Values ranged from 0 to 6 (out of a possible 0 to 6 range), with a mean value of 4.2 (SD: 1.5) (Figure 1). Cronbach's alpha for the full Experiential Scale was 0.623, indicating moderate internal consistency, although consistency is lowered by the inclusion of multiple determinants.

LATRINE UPTAKE

Full data on latrine coverage, latrine functionality, and attitudes towards behaviors was available from 2,200 respondents. Among all respondents, 543 (25%) reported a functional latrine at home; 322 latrines (59% of functional latrines) were completed in the past three years. There were differences in latrine ownership in intervention and control communities. Of the 1,182 respondents in the intervention group, 420 (36%) had access to a complete, functional latrine compared to 123 of the 1,018 respondents from control communities (12%).

Exploratory analysis found evidence of interaction between scale values and intervention status, and regression models related to latrine uptake have been adjusted for this interaction. Among all respondents, living in an intervention community was associated with a 14-percentage point increase in the marginal probability of having a functional latrine (Average marginal effect [AME]: 0.137, 95% Confidence Interval [CI]: 0.094; 0.180). For every one-unit change in the General Scale, individuals had a 5-percentage point increase in the probability of having a functional latrine (AME: 0.051, 95% CI: 0.044; 0.058) (Table 1).

Figure 2 shows the predicted marginal probability of having a functional latrine for the range of possible values of the General Scale by individuals in each group. Among intervention group individuals, the predicted probability of having a functional latrine even with a 0 score on the General Scale was approximately 10% (compared to virtually 0% predicted for control group individuals with a 0 score), with a near linear increase in probability for each additional point on the General Scale. Scores of 10 were associated with approximately 63% predicted probability of having a functional latrine. In the control group, predicted probabilities of having a functional toilet were <10% for General Scale scores <5. For individuals in the control group with General Scale scores ≥ 5 , the probability of having a functional latrine increased steeply as General Scale values increased, with the predicted probability of having a functional latrine in the control group exceeding predicted probabilities in the intervention group for values ≥ 8 . Results at the extreme ends of the General Scale should be interpreted with caution – only 32 individuals in the control group had scores ≥ 8 , adding to the statistical uncertainty of predicted probabilities.

LATRINE USE

Among the 543 individuals that reported access to a functional latrine, 128 (24%) reported engaging in open defecation at least once in the 7 days prior to data collection. Self-reported open defecation among respondents with access to a functional latrine was similar in intervention and control groups (24% and 21%, respectively).

The predicted probabilities of engaging in any open defecation within the last 7 days had an inverse linear relationship with both General Scale and Experiential Scale scores. We determined a 4% point decrease in the probability of engaging in open defecation for every 1-point increase in the General Scale (AME: -0.039, 95% CI: -0.055; -0.010) and an 8% point decrease in the probability of engaging in open defecation for every one-unit increase in the Experiential Scale (AME: -0.077, 95% CI: -0.024; -0.054) (Table 1). Figure 3 plots the predicted probability of engaging in open defecation among those individuals with access to a functional latrine by both General Scale values (range 0 to 10, bottom x-axis) and Experiential Scale values (range 0 – 6, top x-axis). Values of 0 on either scale were associated with a predicted probability of engaging in open defecation among those respondents with access to

a functional toilet decreased linearly with increasing scores on both the General and Experiential Scales.

DISCUSSION

Our data collection and analysis approach resulted in two scales – the General Scale and the Experiential Scale – that provided a simple measurement system for many of the theorized determinants of sanitation use and adoption, including attitudes towards open defecation, social norms, and perceptions of latrine attributes. The determinants that emerged in our initial analysis and that served as the subsequent basis for scale development closely mirror factors associated with latrine adoption, use, and non-use identified in qualitative research conducted within the same study population²³, particularly the important role that existing behavioral patterns play in determining latrine uptake and the importance of perceived convenience in decisions to use available facilities. Both of our scales demonstrated robust psychometric properties, and the strong, clear relationship both scales had with behavioral outcomes is an important indicator of validity and utility. We found strong interactions between our scales, which quantify measurable opinions and social norms related to sanitation, exposure to the TSC intervention in the community, and adoption of household toilets.

The 35% coverage in latrine ownership among intervention households is consistent with the effects seen in the main RCT and other evaluations of sanitation interventions in India and elsewhere ^{11, 12, 16}. While increased uptake of toilets was correlated with the TSC intervention group, opinions and social norms played a critical role in changes in both intervention and control groups. Households with less positive opinions of open defecation, greater perceived social norms regarding latrine use, and fewer reservations about feces and fecal management were more likely to own functioning latrines. Researchers have noted the strong cultural roots of open defecation practices in South Asia ^{17, 35}, and overcoming many of these deeply held beliefs and practices presents a challenge for sanitation programs.

Direct exposure to both toilets and individuals using toilets, a factor closely related to our descriptive norms measure, was a key determinant of adoption in studies in northern India ¹⁷ as well as Africa ³⁶. In a sociometric analysis of data from southern India, Shakaya et al. ³⁷ found individual latrine ownership was significantly predicted by latrine ownership within an individuals social network. Increasing the visibility of socially desirable behaviors and commitment to behavior change have been shown to be effective with respect to hygiene interventions ^{38, 39}. Reinforcing the visibility of and commitment to sanitation may be an effective means for improving attitudes and subsequent behaviors. A simple linear understanding of the causal pathways between norms and behaviors, however, is an oversimplification of a dynamic and mutually reinforcing process. For example, people may change their own behaviors in response to their empirical assessments

of the number of people around them practicing a specific behavior, strengthening the influence these same norms have on the behaviors of others.

Our analysis underscores the necessary balance between interventions that focus on subsidies (such as the TSC) and interventions that foster demand for latrines, such as sanitation marketing ⁴⁰ or community-led total sanitation (CLTS) ⁴¹ approaches. In our study, subsidies for latrine construction were associated with increased access to a functional latrine among those individuals with lower General Scale values. The comparative advantage of subsidies was less pronounced among individuals with higher scale values, suggesting that positive attitudes towards sanitation can lead to improvements in sanitation uptake in the absence of financial incentives.

Latrine uptake, however, is only the first step in effective sanitation programming. Much of the persistent open defecation pattern can be explained by the factors identified in our analysis. Individuals with a more favorable attitude towards the attributes and convenience of their own latrine were less likely to engage in open defecation. Coffey and colleagues ¹³ argue that the smaller size of pits in government of India-financed latrines influences low rates of reported latrine use. Routray et al.²³ found that concerns about rapid filling and frequently emptying of small latrine pits were particularly salient drivers of behavior among individuals with government-financed latrines²³. Our data support this finding, and highlight the need to engage with end-users on the design and placement of new latrines as part of any sanitation intervention. Both the SaniFOAM ³² and IBM-WASH Frameworks ³¹ - two theoretically informed behavioral frameworks related to sanitation, highlight the need to consider the role that intervention technology plays in determining uptake and consistent use. One specific aspect central to attitudes towards the specific sanitation technology was water access. Users who had difficulty finding and securing water for use in sanitation – a necessity with the poor flush toilets promoted as part of the TSC – had lower experiential scores and a lower probability of exclusively using household latrines. Oualitative studies in eastern India have found that water resources not only influences latrine use²³, but securing water for sanitation and sanitation-related behaviors is a major contributor to sanitationrelated psychosocial stress among women⁴². Our study supports this emerging body of literature outlining the need for policies and implementation strategies that consider the relationships between sanitation and water access at the householdlevel.

Our findings differ from other studies in a few key ways. Contrary to Coffey et al.¹³, we found that the vast majority of respondents were aware of the potential community health benefits associated with sanitation. Injunctive norms, norms related to what an individual perceives as socially accepted behavior within their larger social network, have been suggested as a tool for triggering and maintaining improved sanitation behaviors^{43, 44}. Injunctive norms are closely tied to strategies of "shame and blame" utilized in various sanitation programs. However, data on their impact are limited. Qualitative studies in Zimbabwe⁴⁵ and Benin³⁰ have found that

avoiding shame or embarrassment and a desire for social prestige were important drivers of sanitation adoption. In India¹⁶, "shame and blame" strategies alone were less effective at increasing latrine ownership than strategies which also provided economic subsidies. In our study, injunctive norms did not emerge as a salient factor in the initial qualitative phase of our study nor were our imposed measures of injunctive norms robust enough for inclusion in the final analysis. While interventions that reinforce social expectations may be an effective means to maintain behaviors, they may not be sufficiently salient to regulate behaviors in this setting – quite plausible given the low rates of sanitation coverage and general lack of stigma or shame attached to open defecation.

Our analysis highlights the potential utility of robust scale development approaches in understanding the attitudinal factors that shape behaviors, complimenting existing ethnographic and other qualitative approaches. There is a general understanding that attitudinal and psychosocial factors are important predictors of uptake and use of environmental health technologies ³⁰⁻³². Because these factors are unobservable and no "gold standard" measurement exists, they have been largely ignored or overlooked in quantitative impact and outcome evaluations. Scale development, the process of identifying groups of questions that in some way reflect these latent, unobservable factors, provides an opportunity to measure these unobservable factors. Applied scales could be conceivably used to both track changes in the attitudinal factors that shape uptake and use, as well as provide guidance on targeted messages and behavior change communication to effectively leverage determinants most associated with improved behavioral outcomes.

There is a wide range of scale development techniques available for researchers and the integration of commands and functions for the most common approaches are now standard in most statistical packages. However, it should be noted that scale development is less mechanistic than traditional statistical analyses – the interpretation and judgment of the researcher is paramount to the successful development and interpretation of these scales. Scales are, in many ways, a form of interpretive statistics, independent of meaning save for those assigned by the researcher.

We have identified specific factors associated with latrine uptake and use within a specific population and their application within a different context should be taken with caution and adapted appropriately. The specific set of attitudinal factors and constellation of questions that best reflect these factors will differ between populations and household technologies. For example, our experiential scale reflects direct engagement with the pour flush latrines promoted as part of the TSC in Odisha and the specific questions less generalizable to populations were other sanitation technologies are more common.

We have outlined our process for identifying and measuring the latent, attitudinal factors related to sanitation uptake and use. The scale development process includes a flexible set of methods and approaches – the process outlined here is but

one of many options available to researchers. Simpler and less time and resource intensive models exist – for example, Phase 2 and Phase 3 of the methods outlined can be completed simultaneously provided sufficient sample size and data collection design. *Adaptation* of our proposed scales does not require the full mixed methods approach outlined in this manuscript, but rather the application of simple yes/no questions related to sanitation uptake and use within a population and an assessment of how these questions relate to the scales described here.

Due to the focus on attitudinal factors, our analysis did not capture larger, more contextual determinants of behaviors (e.g., political will, political economy). In order to focus on the process of scale development and the relationship between attitudinal factors and latrine uptake and use, we have also not adjusted for a range of other possible confounders. The net impact of attitudinal factors and other potential determinants of our outcomes will be explored in greater detail in subsequent analyses. Our study is cross-sectional and we are unable to fully establish causality. We cannot be certain if individuals with a less favorable view of open defecation, for example, were more likely to invest in a new latrine when engaged with the TSC or if individuals with a new latrine subsequently developed less favorable views of open defecation. Both are likely important, and the causal pathways of many of our determinants are likely dynamic and mutually reinforcing. We are unable to adjust analyses for the gender of the respondent. In the process of generating a quantifiable scale with demonstrated utility, we utilized simple binary behavioral outcomes. Future analyses examining the impact of a wider-range of determinants will explore more nuanced outcome measures. In prior rounds of data collection for the trial, over 98% of respondents were women. Studies have noted that women are likely to use latrines more often than men ^{11, 20}, thus individual reported behavior may be an underestimate of true open defecation practices in the households of respondents. Related work identified sense of ownership and valuation as further influences on latrine usage²².

Addressing the current sanitation challenges in low- and middle-income countries will require interventions that both overcome the economic barriers to latrine ownership and influence the psychosocial and attitudinal factors that influence consistent latrine usage. Here we present a contextually specific approach to derive empirically valid scales, novel in the sanitation field, which revealed preferences surrounding latrine adoption and use. We found evidence that our scales are internally valid and statistically correlated with adoption and use. The approach we present, and these scales themselves, could be adopted for future work within India, in order to assess baseline attitudes surrounding toilet construction and use, and to track if an intervention is successful at changing these attitudes.

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Table 1: Final set of 10 questions summed in the calculation of the General Scale by determinants and question specific Loevinger H values (n = 2202).

Determinant	Questions	Loevinger
(Leovinger H*)		Н
Attitudes towards open defecation (0.578)	*Taking a stroll in the evening is an important benefit of going for open defecation.	0.580
	*I enjoy the freedom (<i>khola</i>) of going for open defecation	0.722
	*I dislike the feeling of confinement (<i>abodh heba</i>) when I defecate in a latrine.	0.543
	*OD gives the opportunity to "get out of the house" and socialize with my friends.	0.500
Attitudes towards feces / fecal management (0.518)	*It is a sin to store feces in the latrine pit close to house.	0.518
	*It is unhygienic to store feces in a latrine pit close to the home.	0.518
	I think that most of the men in my village are regular users of the latrine throughout the year	0.616
Descriptive norms related to sanitation (0.594)	My relatives all use a latrine when they go to defecate.	0.557
	People in this village do not go for open defecation during the rainy season	0.547
	I think all of my neighbors regularly use a latrine.	0.648

Questions discarded in final analysis:

Attitudes towards open defecation

Elderly people are habituated with OD, they cannot adopt latrines -

Injunctive norms

- An important reason to have a latrine is for use by guest
- -Latrine used by father in law should not be used by daughter-in-laws

* Indicates questions were response categories were coded so that "disagree" – the response supportive of latrine adoption - had a scale score value (count) of 1, otherwise "agree" was coded as a value of 1.

Table 2: Final set of 6 questions summed in the calculation of the Experiential Scale by determinants and question specific Loevinger H values (n = 920).

Determinant	Questions	Loevinger
(Leovinger H*)		Н
Perceived attributes of household latrine (0.535)	*Accessing water for bathing after latrine use is difficult	0.586
	*The pit is small and would fill too quickly if everyone used the latrine every day	0.431
	*It is too much work to get water to use the latrine at night	0.565
Perceived latrine convenience (0.683)	*By regular use of the latrine, I miss the opportunity to go out of the house	0.538
	*For the work I do, it is more suitable to go outside the house to defecate	0.740
	*It is often more convenient to defecate outside than to return home to use the latrine	0.730

Questions discarded in final analysis:

Perceived attributes of household latrine

- The cabin of the latrine is too small for me to use

Perceived latrine convenience

- In the morning, it is more convenient to defecate outside than to return home to use the latrine

Attitudes towards shared sanitation:

- There are too many people in this household for just one latrine
- I have to wait for too long in the morning before it is my turn to use the latrine

* Indicates questions where response categories were coded so that "disagree" – the response supportive of latrine adoption – had a scale score value of 1, otherwise "agree" was coded as 1.

Table 3: Average marginal effects (AME) for General and Experiential Scales against selected behavioral outcomes, calculated from multi-level logistic regression model with community-specific random intercepts

	Has access to a functional latrine* at home (n = 2200)**		Self-reported any open defecation in last seven days among individuals with functional latrines (n = 536)***	
	AME	95% CI	AME	95% CI
Intervention	0.137	0.094; 0.180	0.012	-0.076; 0.100
General scale	0.051	0.044; 0.058	-0.039	-0.055; -0.010
Experiential scale			-0.070	-0.024; -0.054

*Functional latrine defined as a self-reported toilet and/or latrine at home that is operating correctly and where roof and pan are both completed.

** Model included intervention status, General Scale score, and the interaction term of the two.

*** Model included intervention status, General Scale score and Experiential Scale score.



Figure 1: Box plots of final General Scale scores (n = 2202) and Experiential Scale scores (n = 940)

Figure 2: Predicted marginal probability (with 95% confidence interval) of having a functional latrine at home by General Scale scores among respondents in intervention and control communities (n = 2200)



Figure 3: Predicted marginal probability of engaging in any open defecation in the last seven days by General Scale (bottom axis) and Experiential Scale (top axis) scores among individuals with a functional latrine at home (n = 536).



