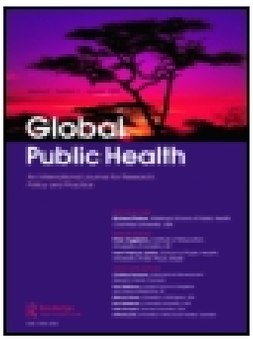

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Women 'holding it' in urban India: Toilet avoidance as an under-recognized health outcome of sanitation insecurity

Sarita Vijay Panchang[a], Pratima Joshi[b] and Smita Kale[b]

[a]Social Research & Evaluation Center, Louisiana State University, Baton Rouge, LA, USA; [b]Shelter Associates, Flat A/17 Sarasnagar Siddhivinayak Society, Pune, India

ABSTRACT

Emerging research on sanitation challenges in the Global South increasingly uncovers health and social impacts by gender, particularly lack of sanitation safety. Women may employ strategies to avoid urination or defecation ('holding it') in the absence of safe sanitation, but the practice is not well understood. We quantitatively analyze survey data on women from urban slums across three cities in Maharashtra, India whose households constructed a toilet through an intervention programme. We assess relationships between household versus shared sanitation, perceptions of safety, and women's toilet avoidance behaviours, including diet restriction. At baseline, women have more than three times the odds of reporting avoidance behaviours if they perceive a community toilet to be unsafe, even after controlling for other factors. Household water insecurity is also instrumental in the relationship between avoidance and lack of safety. Finally, avoidance exhibits a significant and major drop upon provision of a household toilet. This study provides substantial support for the prevalence of habitual toilet avoidance among vulnerable urban women without access to safe sanitation. We conclude with recommendations for policy approaches and call for more attention to the health repercussions of habitual toilet avoidance among women as a consequence of sanitation insecurity.

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WASH; gender inequality; urban; informal housing; South Asia

Introduction

Gender and sanitation safety

Approximately 2.4 billion people around the world use unimproved sanitation facilities, with most residing in Asia and Sub-Saharan Africa, and 40% in Southern Asia alone (WHO-UNICEF, 2015). Although the Millennium Development Goal (MDG) to halve the world's proportion of people without safe water was met ahead of schedule, the corresponding sanitation target was missed (WHO-UNICEF, 2015).

Gendered aspects of sanitation are yet being uncovered; while efforts to 'include' women in development have been in place for some time, how to meaningfully address gender beyond token efforts such as inviting women to serve on WASH committees, has proven to be a challenge (Tilley et al., 2013). One way of addressing gender more meaningfully has been to expand understandings beyond traditional health indicators such as gastrointestinal illness (e.g. Prüss-Ustün et al., 2014) to consider sanitation a multilayered issue with both direct and indirect health implications, and specific dimensions across the life course (Pearson & McPhedran, 2008).

CONTACT Sarita Vijay Panchang spanch4@lsu.edu Social Research & Evaluation Center, Louisiana State University, 313 Hatcher Hall, Baton Rouge, LA 70803, USA

Anthropological work, for example, illustrates the use of culturally sensitive methods to elicit expressions of women's *embodied suffering* around water and sanitation (Ennis-McMillan, 2001; Sultana, 2011) while emergent mixed-methods research dives into place, collective factors, and cultural norms to elucidate social, environmental, and infrastructural issues that converge around women's sanitation routines (Winter et al., 2019). Sahoo et al. (2015), for instance, found that among both urban and rural Indian women, 'sanitation' entails not just urination and defecation, but also fetching water, changing clothes, menstrual care, anal cleansing, and post-defecation cleansing of hands and feet. Importantly, in their study most of these behaviours took place outside of an actual latrine.

Researchers also outline several social and environmental pressures that cause stress for women seeking safe, private locations for sanitation needs: Injury from crossing streams or railway tracks is common, as is injury from attacks by animals or insects. Gender roles that pose demands on women's time or which restrict their movement outside of the home may limit their ability to freely attend to sanitation needs. Tensions within the community can also cause competition over communal water and sanitation resources. Perhaps most concerningly, women risk sexual harassment and assault when defecating in the open or using common toilets. All of these experiences have emerged surprisingly consistently across a wide range of recent studies from India (Hirve et al., 2015; Hulland et al., 2015; Khanna & Das, 2016; Kulkarni et al., 2017; Sharma et al., 2015); still more documentation of such challenges emerges worldwide, especially from the 'gray' literature by program-implementing organisations (Sommer et al., 2015). In these literatures, women are reported to cope with constraints by exerting 'control' or 'discipline' over their bodies, which refers to strategies to avoid urination or defecation – including the restriction of food and liquid intake throughout the day. The specific practice of toilet avoidance has not been extensively studied nor have its health implications been examined, although it has been linked to UTI symptoms in at least one case (Kawade et al., 2019). Given the sensitive nature of this kind of 'toilet insecurity' (O'Reilly, 2016), scholars have outlined the need for more fine-grained research to better understand the role that perceptions of safety play in women's sanitation choices (Tilley et al., 2013).

Sanitation in urban informal housing

Urban informal housing – slums and settlements[1] – create unique challenges for sanitation access. While rural areas are frequently thought to be under-resourced compared to urban areas, this view masks considerable variation on smaller scales as well as the 'urban penalty' associated with the relatively high cost of living in cities (Sverdlik, 2011). The struggle of cities to manage demographic shifts from rural to urban areas is exhibited by the large proportions of urban slum dwellers across the Global South: between 1990 and 2014, Southern Asia has had one of the highest percentages of urban populations living in slums, second to sub-Saharan Africa (UN-HABITAT, 2016). Rapid urban growth also often outpaces that of public infrastructure, affecting poor populations most severely (Agarwal, 2011): among slum households in India, nearly a fifth are estimated to practice open defecation, and less than a third have their own toilet (NSSO, 2012).

While there is some evidence that slum upgrading strategies affect health (Turley et al., 2013), there is a wide range in administrative approaches toward slums, and statistics on slum populations and access to WASH amenities are thought to be an underestimate (Agarwal, 2011; Sverdlik, 2011). The Indian government's method of formally recognising slums and establishing their eligibility for certain municipal services can lead to variability in how people are counted and what services they are entitled to (Joshi et al., 2011; Nakamura, 2014). Geographic features such as population density, irregular housing growth, insecurity of tenure, and being located on sometimes dangerous or undesirable land, pose challenges for sanitation planning in informal housing (Isunju et al., 2011; Okurut et al., 2015).

Indian sanitation policy context

While the Indian government has long been active in sanitation programming, its main focus has been on rural areas until very recently. The Total Sanitation Campaign (TSC; also called the Nirmal Bharat Abhiyan), which was launched in 1999, signalled a shift away from supply to demand – that is, more emphasis on community-level sanitation promotion and cash subsidies to encourage toilet construction in rural areas. Most recently, the Swachh Bharat Mission, or Clean India Mission (SBM), was launched in 2014 and ended in 2019 (GOI, 2017b). SBM had a more ambitious goal: to end open defecation completely in India by October 2019. SBM has continued a demand-driven approach by connecting with various outside organisations, including the Community-Led Total Sanitation (CLTS) Foundation, which espouses a strategy in which communities undergo activities designed to 'trigger' disgust over open defecation (OD), spurring community-wide efforts to stop the practice (GOI, 2016, 2017b; Kar & Chambers, 2008).

As the SBM reached completion relatively recently, research on its outcomes is yet emerging, although one study suggests that toilet gains have not been as large as official government statistics (Gupta et al., 2019). Research on prior iterations of the TSC indicates an increase in toilet construction, but insufficient usage or abandonment of OD to correspond to health improvements (Barnard et al., 2013; Clasen et al., 2014; Patil et al., 2014; Pattanayak et al., 2007). The social undercurrents within a community, particularly power relations by class, gender, caste, and the influence of local leaders, also have ramifications for CLTS-type programming (Movik & Mehta, 2010). There is documentation of harassment and violence as tactics to discourage OD, which has raised concerns among scholars regarding the ethics of CLTS (Bartram et al., 2012; Hirve et al., 2015).

SBM appears to represent the first iteration of the TSC with more explicit provisions for urban areas and funding from broader corporate social responsibility (CSR) channels that could continue after the programme (GOI, 2017a, 2017b). Efforts in urban areas include stopping OD, eliminating manual scavenging (direct removal of excreta by sanitation workers), and installing public and community toilet blocks where individual toilets are not considered feasible (GOI, 2017a). While the urban arm of SBM thus appears to focus more on infrastructure than community behaviour change, local crackdowns on OD have been anecdotally reported, including in areas that are officially recorded as open-defecation free.[2,3,4]

Greater focus on household toilets in urban slums is a unique feature of SBM, as is its emphasis on sanitation equity (GOI, 2017a, 2017b). It is essential to address difficulties encountered by the urban poor, particularly women, in accessing sanitation on a daily basis, with more granularity on what leads women in urban informal housing to engage in toilet avoidance. Addressing these challenges is also crucial toward achieving the Sustainable Development Goals (SDGs) – not only the sanitation targets, but also those pertaining to inclusive cities and gender inequality.

This study builds on prior scholarship by utilising data from a toilet programme implemented by a nonprofit organisation to assess relationships between household and shared sanitation, perceptions of safety, and women's toilet avoidance behaviours, including diet restriction, within informal housing in urban Maharashtra. As existing research on these relationships has been primarily qualitative, to our knowledge this is the first study to explore them from an in-depth quantitative standpoint.

Methods

Toilet intervention program

This study employs programme data collected by the nonprofit organisation, Shelter Associates (SA). Since 1993, SA has been engaged in community-based housing and sanitation solutions in the state of Maharashtra, India in urban or peri-urban slums and settlements. SA has also been instrumental in documenting and mapping populations in a 'slum census' to better enumerate residents of these settings for improved urban planning (Sen et al., 2003). In the last several years they have implemented a programme called One Home, One Toilet, which facilitates the construction of household pour-

flush toilets in urban slums (Appendix A). Between 1993 and 2014, nearly 3000 toilets were completed through its programmes. Since 2014, through a linkage with the municipal rollout of SBM and funding through CSR channels, more than 18,000 toilets have been built through SA's programmes (Smita Kale, personal communication). The majority of toilets are connected to underground sewerage, but septic tanks are used in smaller or peri-urban settlements, or in the absence of a sewer network. At baseline, sanitation options available to households consist largely of OD or sewer/septic tank-connected community toilet blocks (CTBs) which are provided by the municipality. While CTBs are generally free to use, persons-per-seat ratios often number in the hundreds[5] and ground-level observations in project communities have noted complaints from local residents about their functionality and maintenance.

Data collection

The data for this study consists of SA's impact assessment, a rolling data initiative primarily intended to check whether toilets are functional and being used, which is then reported back to donor organisations. Data from the current wave was collected between 2016 and 2018. Approximately 15% of beneficiary households in each slum are selected for impact data collection. The survey is administered to a consenting female primary respondent at least 16 years of age, and only households who own their home (superstructure) are eligible for the survey. Surveyors attempt to contact each household in the sample three times before excluding it, and aim to oversample households with vulnerable members such as adolescent girls, children, women, or the elderly. The survey consists of items on demographic factors, health behaviours and opinions, and home construction and tenure. A suite of items are asked to the primary respondent on behalf of each member of the household, while specific items, including those on urination/defecation avoidance, are asked only to the primary survey respondent. The baseline (pre-intervention) survey is administered at the start of the household's agreement to build a toilet and the follow-up (post-intervention) survey is administered 8–16 months after the toilet has been completed.

In the baseline survey phase, 758 households were sampled from 3 major cities (municipal corporations) in Maharashtra: Pimpri-Chinchwad (PCMC), Pune (PMC), and Kolhapur (KMC). At the follow-up phase, 579 households were reached, amounting to a 76.4% rate of follow-up. Households were lost to follow-up because sewer lines had not yet been extended into the area so the toilet could not be used, or the family moved or was otherwise unreachable.[6] Households in the final sample were compared with those lost to follow up on several items. Chi-square tests on family type, education, electricity ownership, type of floor, age of constructed house, number of rooms, water source, urination/defecation avoidance, and diet restriction to avoid urination/defecation found no statistically significant differences. For age, a two-sample t-test indicated that primary respondents in the final sample were significantly younger than those lost to follow up (mean age of 30.8 and 33.3 years, respectively, with $p = 0.02$).

Of the 579 households in the final sample, 72 were removed either because it could not be verified whether the primary respondent was of age, as birthdate is not always culturally significant in this context ($n = 27$); the primary respondent in the follow-up was a different individual from that of the baseline survey, meaning that the outcome measure could not be accurately compared ($n = 43$); or both ($n = 2$). The final sample was 507 primary respondents or households, coming from 13 different slums across the three municipalities. This analysis was approved by the University of South Florida Institutional Review Board and by SA.[7]

Survey items

Dependent variable

Dependent variables in this study are modelled separately. They indicate whether the primary respondent *ever avoids urination or defecation*, and whether they *ever restrict food or liquid to avoid urination or defecation*.

In the baseline survey, urination and defecation items were asked separately: for urination, visiting the bathroom every time or sometimes avoiding, and for defecation, visiting every time, sometimes avoiding, and avoiding most of the time. In the post-survey, avoidance was asked about urination and defecation together (visit every time, avoid sometimes, avoid most of the time). To account for this, the items were recoded into a new dichotomous variable called *general avoidance*: *ever* avoiding urination or defecation, versus *never* avoiding urination or defecation.

The item on food restriction asked whether the respondent followed any restrictions on dinner to avoid defecation, while the item on liquid restriction asked whether the respondent avoided drinking water or liquids after dark. These items were asked identically in the pre- and post- phases and had yes/no responses. They were collapsed into a new dichotomous variable, *diet restriction*, indicating whether the respondent ever restricted food or liquid at night to avoid urination or defecation. For both outcome variables, the reference category is *never avoiding*.

Independent variables

This study takes a broad approach towards defining sanitation safety. The current survey included a multiple-choice item on what problems women face when going to the most commonly used area of defecation. Options were CTB distance, lack of electricity (on the road or in the CTB), fear of abuse, fear of animals, and Other. Most cases in the original sample chose multiple options, which is consistent with literature that outlines both interpersonal and infrastructural issues. Because it would be difficult to isolate relationships between avoidance and individual options, we opted not to constrain the definition of safety and instead utilised a single item on *CTB safety*. This is a yes/no answer indicating whether the primary respondent feels the CTB is safe for women (reference = safe). However, we include data on the multiple-choice question in Appendix B as it provides important context on what may inform responses on this item.

Other independent variables are household water insecurity measures, and measures of socioeconomic status (SES). Original categories were collapsed into smaller groups where applicable to adjust for small cell sizes.

Water security: Three water security measures are included. These are binary and show whether the respondent reported: (1) daily water availability, (2) having an individual water tap for the household, and (3) ever treating drinking water.

Socioeconomic status (SES): *Age* is a continuous variable for the primary respondent's age at baseline. *Education* is an ordinal variable reflecting three categories: (1) no education (reference), (2) up to and including 10 years, and (3) more than 10 years' education for the main respondent. *City* is a binary variable for whether the household was in PCMC (reference) or elsewhere (KMC or PMC). *Household size* is a binary variable for less than 5 people in the household (reference), or 5 or more people. *Floor* is a binary variable for properly tiled floor material (*pharashi*; reference) or some other material such as unfinished concrete or mud. *Years in slum* is a continuous variable for the number of years the household has been living in that slum. *Rooms* is a binary indicator of having 1 room only, or 2 rooms or more (reference category). *Possessions* is a summed variable based on a binary item for possession of any of 22 amenities that are included in the Demographic and Health Survey (DHS) household wealth index. Cronbach's alpha for the whole scale was 0.68.[8] There were no missing values in the above variables.

Analytic strategy

Results are shown in two parts. First, we use descriptive statistics to assess change in avoidance behaviours before and after a toilet was constructed. Because almost all respondents who previously engaged in avoidance stopped avoiding with the construction of a toilet (see Results section and Table 1), subsequent analysis models the likelihood of respondents engaging in avoidance behaviours *at baseline*, that is, before a toilet was installed.[9] Results are shown in Table 3 for general avoidance and in Table 4 for diet restriction.

For this part, binary logistic regression (Model A, Tables 3 and 4) is first used to model the odds of a respondent engaging in avoidance behaviour at baseline in relation to each of the independent variables described above. Next, a backwards stepwise multiple regression (Model B, Tables 3 and 4) is conducted to explore the salience of independent variables. Pearson correlation coefficients were first calculated for all candidate predictor variables to check for multicollinearity, with a threshold of $r = |0.7|$ and $p < 0.0001$; none of the variables met these criteria. In addition to the main predictor of interest (CTB safety), the following controls were set to remain in the backwards stepwise regression: city, age, household possessions, and household size. The remaining predictors (education, material of floor, rooms, years in slum, and water security) were selectively eliminated using backwards stepwise regression, with a threshold value of $p < 0.1$ to stay in the model. Finally, based on the results which emerged in the multivariable model for each outcome, an interaction was added to each model (Model C in both tables). SAS University was used for analysis, and all odds ratios are based on Wald chi-square statistics.

Results

Descriptive statistics

First, Table 1 indicates that 16.6% of primary respondents engaged in general avoidance while 21.5% engaged in diet restriction at baseline. The change in these behaviours was almost complete between baseline and follow-up phases. That is, 98.8% of those who reported general avoidance and 88.1% of those who restricted diet at baseline, respectively, stopped these behaviours after toilet construction. The changes are significant for both outcomes at $p < 0.0001$ based on a McNemar's chi-square test. These results indicate that construction of a household toilet corresponded with a near-elimination of avoidance behaviours in the sample.

Descriptive statistics are shown in Table 2. Fully 45% of respondents report that the CTB is unsafe, the primary independent variable of interest in this study. Other statistics show that most of the sample resides in PCMC, and a little over half the respondents have up to 10 years of education. The average age is about 31, with a large range of 16–75 years (SD 11.5). A slight majority has 5 or more people in the home, a properly tiled floor (pharashi), or at least two rooms in the house. Over three-fourths of households report daily water availability or have an individual tap, while just under half report ever treating their drinking water. The average pre-post survey interval was 10.1 months (SD 2.7), while 59% of households made some kind of modification to the home while building the toilet (not shown).

Bivariate results

Model A in Tables 3 and 4 display the results of binary logistic regression for general avoidance and diet restriction, respectively. General avoidance (Table 3A) is significantly associated with perceiving the CTB as unsafe (odds ratio 5.1, $p < 0.001$) and with reporting non-daily water availability (OR

Table 1. Cross-frequencies of avoidance behaviour before and after toilet construction.

		Post		
	Pre	*Avoiding*	*Not avoiding*	Totals
General avoidance	*Avoiding*	1	83	84
	Not avoiding	10	413	423
	Totals	11	496	507
		Restricting	*Not restricting*	
Diet restriction	*Restricting*	13	96	109
	Not restricting	12	386	398
	Totals	25	482	507

$p < 0.0001$ for pre/post change in both outcomes based on McNemar's chi-square test.

Table 2. Descriptive statistics.

Variable	Percent	Variable	Percent
City		Household possessions	9.8 (2.8; 1–18)
PCMC	74.8	Daily water frequency	86.4
KMC or PMC	25.3	Individual water tap	79.7
Education		Ever treating water	49.1
More than 10 yrs	15.4	CTB is safe for women	55.2
Up to, including 10 yrs	53.3		
None	31.4		
Household size		*Continuous variables*	*Mean (SD; range)*
< 5 people	41.2	Years in slum	29.1 (13; 1–80)
5 or more	58.8	Age (pre)	31.5 (11.5; 16–75)
Floor			
Pharashi	57.4		
Coba, mud, other	42.6		
Rooms			
2+	61		
1	39		

13.5, $p < 0.001$). Avoidance is also significantly associated with SES: not living in PCMC, having a non-pharashi floor, and living in the slum for more time.

Modelling diet restriction (Table 4A) uncovers some parallel relationships. Reporting the CTB as unsafe for women is associated with three times higher odds of engaging in diet restriction (OR 3.1, $p < 0.001$). Water insecurity also emerges, although in this case it is not water frequency, but rather having a non-individual water source that is associated with diet restriction (OR 2.6, $p < 0.001$). Living in the slum for a longer period of time is marginally significant and positive. Surprisingly, those who report never treating water have slightly lower odds of restricting their diet.

Multivariable results

Model B of Tables 3 and 4 display the result of the backwards stepwise logistic regression, keeping the predictor of interest (CTB safety) and four controls: city, age, possessions, and household size.

For general avoidance (Table 3B), the stepwise procedure retains material of floor, number of years in the slum, and water frequency, alongside CTB safety and the controls. First, lack of CTB

Table 3. Regression models predicting general avoidance (ever avoiding urination/defecation).

	Model A		Model B[1]		Model C[2]	
Variable	OR	95% CI	OR	95% CI	OR	95% CI
City KMC/PMC	4.727	2.892–7.726***	3.101	1.609–5.977***	2.610	1.310–5.199**
Age	1.013	0.994–1.033	0.995	0.971–1.020	0.998	0.972–1.024
Possessions	0.977	0.900–1.061	1.041	0.931–1.163	1.048	0.936–1.173
Household size 5 or more people	0.978	0.608–1.573	0.839	0.46–1.531	0.859	0.461–1.601
CTB unsafe	5.103	2.977–8.746***	4.443	2.386–8.275***	2.775	1.384–5.560**
Education: Up to, including 10 years	0.621	0.373–1.032				
More than 10 years' education	0.604	0.287–1.267				
1 room in house	0.897	0.553–1.455				
Non-pharashi Floor	1.605	1.003–2.569*	2.699	1.467–4.966**	2.90	1.545–5.444***
Years in slum	1.020	1.002–1.039*	1.027	1.005–1.049*	1.024	1.001–1.047*
Non-daily water frequency	13.451	7.573–23.890***	8.566	4.194–17.495***	1.734	0.349–8.611
Non-individual household water source	0.994	0.555–1.780				
Never treat water	0.720	0.449–1.153				
Non-daily water X CTB unsafe					9.678	1.569–59.702*

Results of bivariate regression (Model A), multiple backwards stepwise regression (Model B), and addition of interaction (Model C), using Wald chi-squares. Italicised variables selected to stay in multivariable models.

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

[1]$n = 507$; AIC = 342.524.

[2]$n = 507$; AIC = 337.178.

Table 4. Regression models predicting diet restriction (restricting food or liquid intake at night to avoid urination/defecation).

	Model A		Model B[3]		Model C[4]	
Variable	OR	95% CI	OR	95% CI	OR	95% CI
City KMC/PMC	1.030	0.634–1.674	1.019	0.593–1.75	1.065	0.616–1.84
Age	1.010	0.992–1.028	1.010	0.991–1.03	1.011	0.991–1.031
Possessions	1.044	0.968–1.127	1.063	0.972–1.163	1.065	0.973–1.167
Household size 5 or more people	1.153	0.747–1.780	1.064	0.656–1.728	1.062	0.653–1.727
CTB unsafe	3.051	1.956–4.759***	3.492	2.162–5.64***	3.023	1.733–5.275***
Education: up to, including 10 years	1.068	0.661–1.725				
More than 10 years	1.064	0.550–2.059				
Non-pharashi Floor	1.430	0.935–2.189				
1 room in house	1.301	0.847–1.998	1.670	1.016–2.743*	1.719	1.041–2.84*
Years in slum	1.016	0.999–1.032	1.019	1.001–1.038*	1.019	1.001–1.038*
Non-individual household water source	2.585	1.605–4.163***	2.754	1.634–4.64***	2.091	0.964–4.536
Never treat water	0.611	0.398–0.938*	0.677	0.427–1.073	0.689	0.433–1.096
Non-daily water frequency	1.470	0.825–2.616				
Non-individual water X CTB unsafe					1.678	0.581–4.841

Results of bivariate regression (Model A), multiple backwards stepwise regression (Model B), and addition of interaction (Model C), using Wald chi-squares. Italicised variables selected to stay in multivariable models.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
[3]$n = 507$; AIC = 491.845.
[4]$n = 507$, AIC = 492.921.

safety remains significant (OR 4.4, $p < 0.001$). Non-daily water availability also remains significant (OR 8.6, $p < 0.001$). As with the bivariate models, not living in PCMC, not having a pharashi floor, and living in the slum for more time are all associated with general avoidance.

In the stepwise result for diet restriction (Table 4B), results are similar to respective bivariate results as well. Reporting the CTB as unsafe for women is still significantly associated with diet restriction (OR 3.5, $p < 0.001$). Having a non-individual water source also persists as a predictor of diet restriction (OR 2.8, $p < 0.001$), as well as the number of years living in the slum and having only one room as opposed to 2 or more rooms.

Given the salience of water insecurity thus far, interaction effects between water insecurity and lack of CTB safety were considered. In India, water rather than paper is commonly used for anal cleansing. CTBs in this context generally do not have water on site, or if they do, it is often in a large open tank, not a faucet. Ground-level observations indicate that users usually bring water from home in a mug or bucket to go to the CTB. As such, women who feel the CTB is unsafe *and* who live in a water insecure household may be particularly likely to avoid defecation or urination than others. Thus, an interaction with CTB safety was added to each multivariable model based on the water insecurity measure which had been significant up to that point: water frequency for general avoidance and water source for diet restriction.

Model C of Table 3 shows that an interaction between CTB safety and water frequency is significantly related to general avoidance. Based on the bar graph in Figure 1 which depicts predicted probabilities in this model, it is clear that among those who feel the CTB is unsafe, respondents who report non-daily water are much more likely to engage in avoidance than those who report daily water. This distinction is not very noticeable among those who feel that the CTB is safe. In the regression tables, the main effect for water frequency is no longer significant while the main effect for CTB safety remains significant; this suggests that CTB safety is still independently associated with avoidance. The Akaike Information Criterion (AIC) of Model C is slightly lower than in Model B, suggesting that the interaction enhances model fit.

For diet restriction, Model C in Table 4 shows that the interaction between CTB safety and water source is not significant, with the main effects largely unchanged. This suggests that lacking a household water source *alongside* reporting the CTB as unsafe does not correlate with diet restriction any more than these features do on their own. This model's AIC is slightly higher than the previous one, further indicating that the interaction does not improve fit.

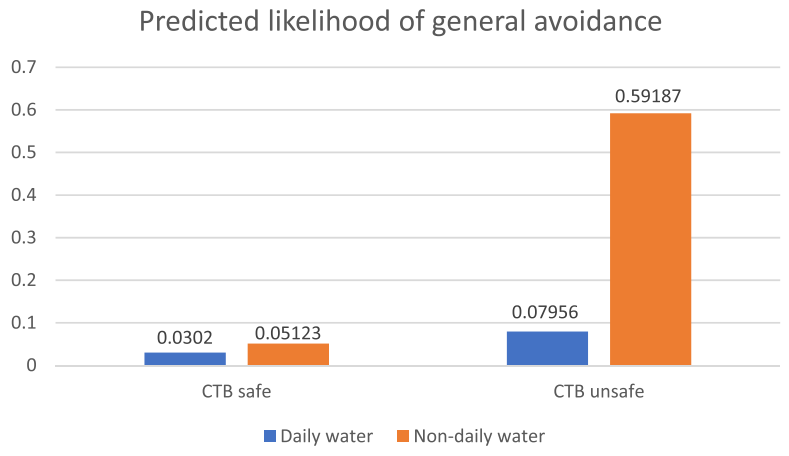

Figure 1. Predicted probabilities of reporting general avoidance based on interaction between water frequency & CTB safety (Model 3C).

Discussion

This study bolsters a growing body of research pointing to the impact of sanitation insecurity on women's quality of life. While our literature review describes sanitation challenges and safety concerns, the specific practice of toilet avoidance has often been a secondary observation. Our study uncovers routine urination and defecation avoidance strategies in direct relation to lack of perceived sanitation safety. In this analysis, we found that the rates of general avoidance and diet restriction went from baseline levels of 16.6% and 21.5%, respectively, to 2.2% and 4.9% after the construction of a sewer-connected household toilet. While there is no control group in this sample, these results suggest strongly that the household toilets were being used enough to correspond to a reduction in toilet avoidance. Multivariable regression illustrates that respondents who found the local CTB to be unsafe for women at baseline had more than four times the odds of reporting general avoidance and more than three times the odds of reporting diet restriction than women who thought the CTB was safe. This was the case even after controlling for several socioeconomic indicators.

Water insecurity measures also emerged within this relationship. Water frequency was salient to general avoidance, largely explained by a significant interaction with lack of CTB safety, such that women who report less than daily water frequency *and* who found the CTB unsafe were especially more likely to engage in avoidance. For diet restriction, those who did not have their own water source were more likely to engage in diet restriction, although no interaction was found between water source and safety. These findings reinforce important intersections between gender and the built environment within urban slums (Joshi et al., 2011). They also affirm the interrelatedness of water and sanitation even though the two infrastructures are often approached separately (Isunju et al., 2011). Using household water rather than paper for cleansing during defecation is common in India, and if women feel that this resource is scarce, it makes sense that they may prioritise its use for other household needs or for other people in the home, such as children. Conversely, since household toilets also do require water for maintenance, the implications of this on the potential for toilet avoidance among water-scarce households is an area for future study.

Certain socioeconomic factors emerged as well, though the effects were not uniform. Those not located in PCMC had slightly higher odds of general avoidance, which might point to city variations in urban planning and infrastructure. The number of years spent in the slum was also positively associated with both kinds of avoidance. It is possible that after migrating from rural settings, women householders may initially be comfortable with CTBs but become more uncomfortable over time. Alternately, gradual slum growth and formalisation may ironically lead to *more* growth,

crowding, and a greater demand placed on CTBs which leads to deterioration. Future work on this topic could build on prior scholarship emphasising linkages between tenure security, WASH practices, and infrastructure access in urban informal housing (Isunju et al., 2011; Joshi et al., 2011; Panchang, 2019). In addition, we found that having a non-pharashi floor is positively associated with general avoidance, while having only one room in the house is positively associated with diet restriction. This provides some evidence for the impact of material household disadvantage on toilet avoidance – possibly, women in more disadvantaged households may have competing demands on their time and energy and be less inclined to attend to their own toileting needs. Conversely, other commonly used SES measures such as household possessions or education level were not salient to the models. The difficulty of assessing the role of household wealth at a granular level is well-documented (Howe et al., 2008), and more research on how SES might shape avoidance among poor women would be useful.

This study has a few key limitations: namely, that there is no control group, and data is self-reported, both of which introduce potential for bias. While a control group would be the most valid way to quantitatively assess changes in toilet avoidance, this was not possible due to ethical reasons. A third-party impact analysis of SA's work, however, does employ a control group and showed large overall changes in toilet avoidance along with perceptions of safety and privacy among households who constructed a toilet (Gokhale Institute, 2018). Another possibility would be to use 'hypothetical' controls from secondary data (propensity score matching), but the authors are not aware of any other publicly available survey which contains items on toilet avoidance, which further underscores that this issue does not seem to be widely recognised.

Selection bias may also be present since householders choose of their own accord to participate in SA's toilet programmes. Some research suggests that going out for defecation can be an important time for women to socialise and be free of surveillance in the home. It is possible that women who prefer the CTB and feel it is safe may not express an interest in a toilet and therefore would not be reflected in this dataset. However, data from the conclusion of the SA's programme operations across slums from this sample indicates that a total of 8289 households out of 13,469 expressed interest in a household toilet, amounting to a 62% rate of sanitation demand.[10] This level of demand indicates that while those who avoid the CTB or feel it is unsafe may not represent all slum households, the strength of the relationships outlined here strongly suggest that this is not a niche group but a substantial population.

Finally, in comparing avoidance before and after toilet construction, there appears to be a very small amount of change in the reverse direction – that is, respondents who were not avoiding at baseline who then reported avoiding in the follow-up phase ($n = 10$ for general avoidance, $n = 12$ for diet restriction). While we cannot speculate here as to exactly why this is, it is possible that women in larger families may attempt to limit their own usage of the toilet to prevent blockage. In small homes, there might also be discomfort with using the bathroom while others are present nearby.

Moreover, the issues that constitute lack of sanitation safety are complex and, as suggested in Appendix B, likely interrelated. Given this, our approach toward safety has been intentionally broad, but further research that probes more deeply into specific connections between types of safety and avoidance would be useful. Mixed-methods and qualitative analyses have already highlighted important cultural, environmental, and geographic dynamics (Hirve et al., 2015; Hulland et al., 2015; Okurut et al., 2015; Winter et al., 2019), and we suggest that more of this type of research could lend valuable insights into trends in toilet avoidance among women.

Conclusion

In this study, we examined perceptions of safety of shared sanitation and defecation/urination avoidance behaviours among women in urban slums, the first to our knowledge to quantitatively analyze these relationships. Our study indicates that women without household toilets do employ strategies to avoid urination and defecation to a substantial degree, and that these behaviours strongly correlate

with lack of perceived safety of common sanitation options. This phenomenon – and its long-term health repercussions – have gone largely unexplored in the international health literature.

Our research prompts several policy considerations. First, while gender inequality in sanitation seems to be readily recognised in rural areas (e.g. Khanna & Das, 2016), we suggest that more attention should be paid to urban settings. This leads to our second observation: the emphasis on SBM-Urban to expand public and communal toilets, while laudable, may not be sufficient to ensure improved, safe sanitation, a point that has been argued by other scholars (Sahoo et al., 2015). Sanitation promotion as a part of SBM has been more extensively described for rural areas (GOI, 2017b), but this study suggests that more critical planning and mobilisation measures are necessary in urban communities, particularly informal housing settings which already face other vulnerabilities. Rather than utilising shame-based methods, we suggest that these measures address the need for appropriate infrastructure alongside issues of harassment, violence, and equity so that all members of the community can feel safe addressing their sanitation needs. This may entail an increase in investment into sewer-connected household toilets or a commitment to improve and maintain CTBs, or perhaps both. Although sexual violence against women is an issue of gender imbalance and may not be solved on its own through the provision of household toilets (O'Reilly, 2016), household toilets do represent a promising step forward in improving the sense of safety and privacy women have when conducting daily sanitation activities. Given that a key aspect of the SDGs is to recognise the interconnectedness within international development, these findings underscore the importance of sanitation not only as a crucial aspect of physiological health, but an essential amenity for quality of life and gender parity.

Notes

1. For the purposes of this research, we utilize the terms *slum*, *informal settlement*, and *informal housing* interchangeably to refer to housing that is unrecognized or semi-recognized by the state. We also draw from the UN-HABITAT's definition: 'A slum household [is] one in which the inhabitants suffer one or more of the following 'household deprivations': lack of access to improved water source, lack of access to improved sanitation facilities, lack of sufficient living area, lack of housing durability and lack of security of tenure' (UN-HABITAT, 2016, p. 2).
2. Pune Mirror, 2019: https://punemirror.indiatimes.com/pune/civic/open-defecation-leads-to-plaints-of-harassment-at-slum-in-taljai/articleshow/69403323.cms.
3. Hindustan Times, 2017: http://www.hindustantimes.com/mumbai-news/mumbai-s-dirty-secret-out-in-the-open/story-tDSkqPwyeswBFgqS7TJiKI.html.
4. India Today, 2017: https://www.indiatoday.in/india/rajasthan/story/rajasthan-activist-lynched-by-civic-officials-983207-2017-06-17.
5. Infrastructure data and maps for settlements across several cities is available at https://shelter-associates.org/index.php#map-plugin.
6. Because some of these issues can change over time – for instance, sewer lines may be laid in that area by the municipality later on and the household may then construct a toilet – it is possible that some households lost to follow-up here may be captured in subsequent waves of data collection.
7. Due to SA's policies, and the fact that data pertains to vulnerable human subjects, this dataset is not publicly accessible. Researchers may follow http://www.shelter-associates.org for access.
8. Subsets of the scale broken down thematically had much lower Cronbach's alpha values, so a summed variable for the whole scale was used. While a principal components analysis (PCA) or multiple components analysis (MCA) for non-continuous data are commonly used to construct household possessions scales (Kaiser et al., 2017), an initial MCA suggested little variation (14%) being explained by the first principal component. Also, the way indices are *coded* may be more relevant than the actual weighting method Howe et al. (2008). In this case, all variables in the scale are binary, which may demonstrate higher agreement than scales with a mix of variable types. Finally, the utility of PCA/MCA tends to lie in cross-national or cross-regional studies with a large range in wealth, but the usage of the scale in a more specific population – urban slums in Maharashtra – across a narrow time span likely reduces this variability to some extent.
9. Initial bivariate models were constructed using a binary outcome of change from avoiding to not avoiding in comparison with everyone else, and the results were nearly identical to bivariate models predicting avoidance only at baseline.
10. Supplementary information available upon request.

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Appendix A. Description of SA One Home, One Toilet programme

Shelter Associates (SA) facilitates household toilets through a three-pronged approach: household data collection, household and local infrastructure mapping, and community mobilisation activities, as well as agreements with the municipality to ensure awareness of the project. SA only conducts toilet agreements where households have current access to sewer lines or where the municipality is actively extending the sewer network. Toilet agreements are based on a cost-sharing model. Materials for a 3 ft. by 4 ft. pour-flush squat toilet (*sundaas*) are provided, which includes a predetermined amount of bricks, cement, sand, door, PVC pipe, and other materials required to construct the toilet and connect it to sewer lines. Households are encouraged to build the toilet within about two weeks to ensure the materials do not get used for other purposes or spoil while sitting outdoors. The household takes on the cost of construction, usually through a local mason. Leftover materials can be kept by the household, but any additional material – for instance, if they wish to build a tiled bathing space (*mori*) adjacent to the toilet – must be purchased separately. The stages of mobilisation activities, toilet agreements, material drop-off, construction, sewer connection, and usage, are monitored daily by field staff and reported back to the office staff at the end of each day. As a result, approximately 98% of SA toilets are connected to sewerage or septic tanks (Smita Kale, personal communication).

Appendix B. Problems faced in the primary place of defecation

The following multiple-choice question was included in the survey for the primary respondent: 'What are the problems that women face in going alone to the most commonly used place of defecation?'

409 (80.7%) reported problems while 98 (19.3%) did not have any problems to report.

Those who did report a problem could choose multiple selections, as indicated below. Of those who selected 'other,' the free-text responses were subsequently grouped by similar themes.

Problem Item	N	Percent
CTB is far away	67	16.38
No electricity in CTB	114	27.87
No electricity on road	87	21.27
Fear of animal/insect bites	55	13.45
Fear of abuse	295	72.13
Other (specify):	10	2.44
People drinking nearby, desire for company, fear of thief	5	45.45
General fear	1	9.09
Fear of ghost/spirits	1	9.09
Respondent is partially blind	1	9.09
Nothing additional	3	7.27