RTI's Reinvented Toilet

June 2014 User Studies: Gujarat State, India

Summary Report

RTI INTERNATIONAL

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Executive Summary

RTI International is developing an on-site waste treatment and toilet system designed for communal or shared applications as part of the Bill and Melinda Gates Foundation's (BMGF's) Reinvent the Toilet Challenge (RTTC). RTI's reinvented toilet (RT) system is designed to be a self-contained unit that collects human waste through a squat plate designed for low-water quantity flush, and then separates and treats the waste within the same unit. Urine is treated using electrochemical disinfection, and feces is dried and burned by combustion, in a down-draft gasifier. The treated liquid is designed to be reused within the system for flushing and cleansing—handwashing and anal cleansing—and power is generated through the combustion of solid waste.[1] RTI's first prototype was demonstrated at the Reinvent the Toilet Fair in New Delhi, India, in March 2014.

In 2011, BMGF launched the **RTTC** to promote and fund the research and design of novel sanitation technologies that disinfect human waste, generate renewable resources (e.g., water, biochar), operate without external power or sewer infrastructure, and cost users less than US $.05 daily. RTI and 17 other organizations have received RTTC grants.

In May 2014, the prototype was shipped to and reassembled in Vadodara in Gujarat, India. Beginning in June 2014, a series of focus groups and surveys were conducted with 227 target users in two cities in Gujarat—Ahmedabad and Vadodara—to inform further development of the RTI prototype. Focus group discussions (FGDs) and a short questionnaire (administered to FGD participants) were designed to collect information from potential users of the RTI prototype system on three primary categories of information likely to affect the adoption and use of the final RTI system:

- current behaviors, beliefs, and preferences regarding sanitation
- preferences regarding ideal sanitation facility attributes
- reactions to potential features of the RTI system

RTI's **field testing activities—e.g., assessing users' preferences and testing system performance**—are currently focused on India, with Ahmedabad as the primary city and additional research in Vadodara. RTI is also developing strong partnerships with local government, research and policy institutes, industry, and nongovernmental organizations (NGOs) focused on improving urban sanitation.

Participants in data collection activities were residents of low-income communities in Ahmedabad and Vadodara, recruited using a convenience sampling methodology. Tables ES-1 and ES-2 offer some descriptive statistics of survey respondents, highlighting key demographic and socioeconomic indicators and summarizing primary sanitation facilities used in Ahmedabad and Vadodara, respectively.

Participants were exposed to the RTI toilet system, participated in a question-and-answer session, completed an individual questionnaire, and took part in theme-based focus group discussions. Sessions conducted in Ahmedabad used a video to introduce the RTI system, while participants in Vadodara viewed

[1] See more information on the RTI system at www.abettertoilet.org. df

Table ES-1: User Study Participants: Demographic Characteristics

Data	Observation
Total Participants	227
Male	46%
Female	54%
Average Age	37 years old
Average Household Size	5.3 people
Households w/ members age 50+	27.3%
Households w/ members age <5	30.4%
Households Below Poverty Line*	29.1%
Head of Household Illiterate	18.1%
Head of Household Education	69.2% at least primary education
Years in Community	24.7 years
House Ownership	72.7% own home

* Defined as those having a Below Poverty Line [BPL] card.

Table ES-2: User Study Participants: Summary of Primary Sanitation Facility Usage, by Gender and Location

Data	Observation
Primary Sanitation Facility (All, n=227)	
• Private Toilet	60% male, 47% female
• Public Toilet	20% male, 23% female
• Open Defecation	20% male, 30% female
Primary Sanitation Facility (Ahmedabad, n = 113)	
• Private Toilet	35%
• Public Toilet	41%
• Open Defecation	23%
Primary Sanitation Facility (Vadodara, n = 114)	
• Private Toilet	69%
• Public Toilet	2.6%
• Open Defecation	28%

both the video and the actual prototype, which was available for demonstration purposes only; no user performance testing was conducted. Future field testing will incorporate performance testing as the technology matures.

RTI collaborated with several partners in India, including the Self Employed Women's Association (SEWA) and the Network for Engineering, Economics, Research, and Management (NEERMAN), a Mumbai-based research and consulting organization, to support qualitative and quantitative data collection activities. SEWA recruited participants, and NEERMAN facilitated and moderated the focus group data collection activities and questionnaire administration; both nonprofit partners aided in increasing RTI's understanding of local context and supporting RTI's engagement with participants in Hindi and Gujarati. L&T Technology Consulting, a partner working with RTI on low-cost manufacturing, hosted the user studies held in Vadodara.

Key **user input and feedback** on RTI's technology and user interface are summarized in Table ES-3. Tables ES-4 and ES-5 provide **recommendations** on how these findings should be used to guide subsequent steps in the design and development of the RTI system—including both **potential changes RTI will consider making to the prototype** (in Table ES-4) and **future plans for user-focused data collection** (in Table ES-5).

The user studies conducted provide valuable information on the preferences of users in RTI's target population; however, the data should not be considered representative, given the convenience sampling and methodologies used. Instead data such as these should be used to support near-term technology

and user interface design decisions that must be made and to guide future user-focused data collection efforts.

Table ES-3: Summary of User Input/Feedback on Prototype Features (June 2014)

Topic	Observation
Overall reactions to RTI system	• Perception of high acceptance of RTI system in participants' communities • System perceived as safe
Highly favored features	• On-site waste treatment; liquid reuse (e.g., flush, anal cleansing); solid waste combustion • Decreased community drainage problems • Waste-driven energy generation to power the system; water conservation • Potential mobility of unit
Gender- and demographic-specific considerations	• Strong preference for separate facilities for men and women • Support for urinal; unclear preference for location (inside/outside) and separate pricing • Interest in and evidence of complex preferences related to menstrual hygiene accommodations (e.g., pad disposal, pad vending machine) • Interest in adding handrails and decreasing number of stairs for elderly/disabled access
Toilet interface	• Preference for squat option over seated toilet interface • Strong preference for anal cleansing by water; nozzle or bucket method (as opposed to by paper)
Flush mechanism	• Preference for automated flush (as opposed to manual powered) • Mixed preferences for flush mechanism (hand vs. foot operated)
Cabin and exterior features	• Preference for internal handwashing station • Exterior features desired include door lock; good lighting inside/outside unit
Water reuse	• High acceptance of reuse of water for flushing • Slight majority accept using recycled water for anal cleansing • Preference for water availability for washing • Mixed preferences for use of reuse water for handwashing • Respondents attach strong importance to issue of water reuse for handwashing, despite a lack of clear preference favoring or disfavoring reuse for this purpose
Willingness to pay (WTP)	• Initial evidence of demand and willingness to contribute for initial costs

Table ES-4: Recommendations for Potential System Adaptation	
Data collection findings	**Recommendation for potential system adaptation**
Gender-separated sanitation practices	Clearly identify separate toilet units for men and women; incorporate gender-specific unit attributes (e.g., urinal, menstrual hygiene management (MHM) bin)
Auto-flush preference	Retain automatic flush system
Squat sitting position	Retain design with squat plate
Menstrual disposal bin (presence)	Develop plan for menstrual disposal and (potential) processing menstrual hygiene products in RTI system

Table ES-5: Recommendations for Future Data Collection	
Data collection findings	**Recommendation for future data collection**
Current Sanitation Conditions	
Barriers to use of public toilets: access, location, safety	Explore conceptual barriers to use and practical, system-based barriers
Ideal Sanitation Attributes	
Positive attributes: cleanliness, ventilation	Explore concrete, physical attributes that achieve attractive qualities in system
Water supply	Develop understanding of water use and reuse at sanitation facility and quality of acceptability (e.g., bathing, washing clothes), quantity used, and potential willingness to pay (WTP) for supply; future data collection may focus on issues of water quality preferences and user valuation of water saving
RTI System Characteristics	
Willingness to pay	Characterize demand in the context of real barriers to investment
Menstrual disposal (method); women-specific	Clearly define possible disposal methods and assess user opinions and cultural acceptability; further exploration is needed, and specifically, exploration of the acceptability of use of disposal chute and method of disposal; several potential options to experiment with acceptability include building a mock chute, and adding a mechanism for shredding and burning
Water reuse (e.g., flushing, anal cleansing, handwashing)	Develop understanding of identified concerns regarding use of system's recycled water; build further understanding about attitudes toward behaviors appropriate for water reuse (e.g., handwashing)
Flush pedal operation (hand/foot)	Refine knowledge of preferences (e.g., height, ease of use, best placement) of flush mechanism
Urinal location (inside/outside); male-specific	Develop understanding of preferences and role of monetary (WTP) constraints in relation to urinal addition; future data collection may include experimentation of urinal location and pricing
Stairs, handrail (elderly/disabled)	Understand challenges as they relate to vulnerable demographics suggested in FGDs (e.g., elderly/disabled)
Cabin size	Build understanding of how users value cabin space, preferences related to current cabin size of prototype

1. Introduction

RTI is developing an on-site waste treatment and toilet system designed for communal or shared applications as part of the Bill and Melinda Gates Foundation's (BMGF's) Reinvent the Toilet Challenge (RTTC). The RTTC is promoting the research and design of novel sanitation technologies that disinfect human waste, generate renewable resources, operate without either a networked sewer system or electricity grid, and cost users less than US $.05 daily.

The RTI reinvented toilet (RT) system is designed to capture human waste in a self-contained unit and separate the waste for treatment underneath a low water quantity flush and squat plate.[2] The urine is treated using electrochemical disinfection, and the solid feces is dried and burned through combustion in a down-draft gasifier. The system is designed as a closed loop, in that it uses thermoelectric devices to generate power from the combustion of solid waste—sufficient enough to power the entire system—and treats liquid waste that can be reused. RTI demonstrated its first prototype (referred to as the "pre-alpha" prototype) alongside 16 other units at the Reinvent the Toilet Fair in New Delhi, India, in March 2014.[3]

In May 2014, the RTI prototype was shipped to and reassembled in Vadodara in Gujarat, India.[4] Beginning in June 2014, a series of focus groups and a survey were administered to potential users of the RTI system in two cities in Gujarat; the goal was to inform further development of the RTI prototype and other off-grid technologies more broadly. This report provides a summary of the goals of the June 2014 user studies, the data collection methodologies used, and the results of data analysis. Conclusions and recommendations are provided both for short-term adjustments to be made to the RTI toilet system and for future data collection activities.

2. Data Collection Objectives

The June 2014 user studies were designed to inform ongoing prototype development and to provide input into future qualitative and quantitative user studies by beginning to identify the breath of issues likely to impact future adoption of the RTI system. The focus groups conducted and questionnaires administered solicited data about potential users' sanitation practices and preferences and about their input and feedback on the RTI system. Feedback was collected on the user interface of the pre-alpha prototype, and on the RTI unit's potential as a toilet facility in shared and public settings.

[2] See more information on the low water quantity flush and squat plate at http://abettertoilet.org/roca-sanitario-develops-ultra-low-flush-squat-plate/.

[3] See more information on the RTI unit at the Reinvent the Toilet Fair in India at http://abettertoilet.org/delhi/.

[4] RTI has chosen to focus field testing activities in India, with Ahmedabad as the primary city and additional research being conducted with partners in Vadodara, where the first RTI prototype has been located. RTI has also developed strong partnerships and contacts with local government, research and policy institutes, industry, and nongovernmental organization (NGO) partners working to improve urban sanitation.

Primary research objectives for data collection in June 2014 were to conduct initial assessments of:

- current behaviors, beliefs, and preferences regarding sanitation;
- preferences regarding ideal sanitation facility attributes; and
- reactions to potential features of the RTI system.

Further, RTI sought to collect basic information on current spending and potential willingness to pay for sanitation and on demographic-specific concerns (e.g., gender-specific, age-specific) in order to bolster understanding of heterogeneous preferences throughout the sample of participants and survey respondents.

3. Methodology

3.1 Data Collection

The user studies took place in Gujarat, India, with activities in two cities: Ahmedabad (at SEWA offices) and Vadodara (at L&T's engineering facility). A total of 24 focus group sessions were completed in Ahmedabad, and 12 sessions were completed in Vadodara between June 10 and 19, 2014, for a total of 227 focus group participants.

Participants were recruited by SEWA, a community-based nongovernmental organization (NGO) active in Ahmedabad and Vadodara with operations throughout India. The convenience sample of participants was drawn from low-resource communities with and without private and community toilet facilities. Participants were recruited in community clusters, by Hindu and Muslim religion and grouped by gender and age-defined groups as follows:

1. Women aged 18–30
2. Women aged 31–54
3. Mixed gender group of men and women aged 55 and above
4. Male and female parents with children aged 18 and under
5. Men aged 18–30
6. Men aged 31–54

In Ahmedabad, participants came from Khodiyar Nagar (Patriwali, Chaparawali, and Hanumannagar chawls), Wadaj (Purpidittangar, Madhya Pradesh kiw chawl, Sarangpur Mill-2, and Raijpur Hiralal chawl), and Rakhial (Other Backward Class). In Vadodara, participants came from the communities of Ramnagar, Navayard, and Bharjarvas.

Data collection sessions were conducted twice each day for 2.5 hours each; approximately 20 adults, usually 10 male and 10 female, participated at each meeting. Upon arrival, each group of 20 participants came together in a group meeting setting. The meeting agenda included viewing a short animation video of how the RTI toilet prototype functions and a question-and-answer session of RTI's waste treatment and toilet technology. The meetings in Ahmedabad relied on video and images for discussion, while participants in Vadodara were able to view the video and to view and flush the actual prototype.

After the introductory meeting, a pencil-and-paper questionnaire was administered orally to participants by NEERMAN facilitators primarily in Gujarati, with some conversations supplemented in Hindi. The questionnaire was completed in approximately 30–45 minutes.

After the completion of the questionnaire, each group of 20 participants was broken into two groups of 10 for focus group discussions on 1–2 selected themed topics. In each focus group, which lasted approximately 45 minutes to an hour, participants were all of the same gender.

Focus group discussions (FGDs) focused on a variety of themes, as summarized in Table 1. The four topics for FGDs included defecation behavior, feminine hygiene, community toilets, and RTI sanitation technology. All sessions were moderated by NEERMAN staff; SEWA staff assisted by helping to facilitate communication as needed. Male groups had a male facilitator, and female groups had a female facilitator.

Table 1: FGD Topics Discussed and Survey Participation, by Age and Location

	Defecation Behavior	Feminine Hygiene	Community toilets	RTI Sanitation Technology	Additional Survey
Women 18–30 years					
Ahmedabad	1	1	1	1	2
Vadodara	partial	partial		1	2
Women 31–54 years					
Ahmedabad	1	1	1	1	2
Vadodara		partial	partial	1	2
Men 18–30 years					
Ahmedabad	1	1	1	1	2
Vadodara		1		1	2
Men 31–54 years					
Ahmedabad	1	1	1	1	2
Vadodara		partial	partial	1	2
Men and Women 55–70 years					
Ahmedabad	1	1	1	1	2
Vadodara	partial		partial	1	2
Parents of u18 children					
Ahmedabad	1	1	1	1	2
Vadodara	partial		partial	1	2

Note: Where designated “partial,” the FGD topic was combined with another topic.

During the first 3.5 days of the user sessions, RTI facilitated the work of another BMGF grantee: FIRMENICH, a Geneva-based fragrance firm working on odor control mitigation strategies, conducted data collection with the focus group participants. FIRMENICH gathered data from participants on their reactions to various odors using smell sticks that ranged from pleasant, blank, and unpleasant odors (e.g., urine, feces, and sewage). Where this survey was administered, the RTI questionnaire was not;

participants began with the odor test before discussing the RTI technology. FIRMENICH prepared their own survey and NEERMAN and SEWA assisted with translation. FIRMENICH analyzed these data independently; the results are not included in this report. Additional information on how the data collection materials were developed and administered, as well as procedures used to ensure high data quality and data privacy, can be found in Appendix A.

3.2 Data Processing and Analysis

After data collection was complete, transcripts and unedited notes from the FGDs and data from the RTI survey administration were cleaned and analyzed.[5] Transcripts used in this analysis were developed by NEERMAN using audio recordings and notes from FGD sessions. Audio was captured in all but two FGDs. Unedited notes were provided with transcripts for analysis.

RTI conducted thematic analysis of the focus group transcripts using QSR International's NVivo software. Coding of transcripts was conducted to form broad thematic findings to inform research objectives. NEERMAN conducted qualitative analysis to assess the frequency of topics discussed and determine direction and intensity of participant feedback. RTI and NEERMAN both analyzed survey data using STATA. Further, qualitative and quantitative data were compared to assess consistency across surveys and discussions. Quantitative results are largely descriptive; where regression analyses were conducted, results are not generalizable, given the convenience sample. Regression analyses use either Ordinary Least Squares (OLS) or probit specifications, where appropriate.

The findings from the quantitative survey data and qualitative focus groups have been combined for this report, though the source of the data presented is noted throughout Section 4. When comparing data from the questionnaire on participant characteristics against Gujarat state-level averages, RTI finds that household characteristics such as number of household members, ownership of below poverty line (BPL) cards, and age distribution of members are similar across the sample and state population.[6] Levels of asset ownership also closely match asset ownership levels in urban areas of Gujarat.[7] Despite these similarities, the convenience sampling used does not suggest that these results or the sample used is representative of a larger population.

4. Analysis Results

This section summarizes findings based on primary research objectives, which seek to identify current attitudes and behaviors regarding sanitation, concepts of ideal sanitation, and individual reactions to the RTI system and prototype. The following results sections are organized along these objectives, including: (1) a description of the sample used in quantitative survey data, (2) a discussion of current sanitation facilities and behaviors, (3) themes associated with ideal sanitation, and (4) details of preferences related to the RTI technology.

[5] FIRMENICH retained their questionnaires and analyzed data independently after returning to Geneva.
[6] District Level Household and Facility Survey, 2007–08, Gujarat. http://www.rchiips.org/pdf/rch3/report/gj.pdf
[7] Ibid

4.1 Sample Characteristics

Table 2 outlines basic statistics about the survey respondents, which give context to this report's findings. Survey respondents were approximately evenly divided between men and women, with an average age of 37. Survey respondents have resided in their current communities for nearly 25 years on average, with less than one-fifth of the respondents migrating from within Gujarat or other states in India. Over two-thirds of respondents lived in households (HHs) where the head of household has at least a primary education, which is similar to Gujarat's high educational attainment, relative to the national averages for India.[8] Notably, almost 30% of respondents live in a household with at least one elderly household member (over age 60) or a child (under age 5).

Table 2: Survey Respondents: Descriptive Statistics

Data	N	Mean	Std. Dev.	Min	Max
Respondent gender (male)	227	46.7%	0.50001	0	1
Respondent age	227	36.7	13.75692	17	75
Years residing in community	227	24.7	15.28599	0	71
Non-native resident (migrant)	227	19.8%	0.399553	0	1
Head of household (HH) age	227	39.4	11.38562	18	71
Head of HH is illiterate	227	18.1%	0.385551	0	1
Head of HH has completed primary education	227	69.2%	0.462841	0	1
HH is owned, not rented	227	72.7%	0.446551	0	1
Number of HH members	227	5.3	2.179984	1	14
Number of male HH members	227	2.7	1.45915	0	10
Number of female HH members	227	2.6	1.392056	0	8
HH has members over age 60	227	27.3%	0.446551	0	1
HH has members under age 5	227	30.4%	0.460984	0	1
HH owns below poverty line (BPL) card	227	29.1%	0.455111	0	1
HH Assets					
HH has electrical connection	227	94.7%	0.224255	0	1
HH owns bicycle	226	50.0%	0.50111	0	1
HH owns 2- to 3-wheel auto	226	34.5%	0.476467	0	1
HH owns 4-wheel auto	224	3.1%	0.174382	0	1
HH owns mobile phone	227	90.7%	0.290386	0	1
HH owns color television	227	71.8%	0.450938	0	1
HH owns satellite dish	227	63.0%	0.483883	0	1
HH owns liquid propane gas (LPG) stove	227	59.9%	0.49116	0	1
HH owns refrigerator	227	33.0%	0.471395	0	1
HH owns washing machine	226	5.3%	0.224725	0	1
HH owns water treatment device	227	4.4%	0.205666	0	1
HH owns mosquito net/coil	227	37.4%	0.48505	0	1

[8] On average, males aged six and over have approximately 4.9 years of education nationally, compared to six years in Gujarat. Additionally, only 37% of the male population in Gujarat has not completed primary education, compared to 42.8% across India. For further information, see: International Institute for Population Sciences (IIPS) and Macro International. 2007. *National Family Health Survey (NFHS-3), 2005–06: India: Volume I*. Mumbai: IIPS. http://dhsprogram.com/pubs/pdf/FRIND3/FRIND3-Vol1AndVol2.pdf

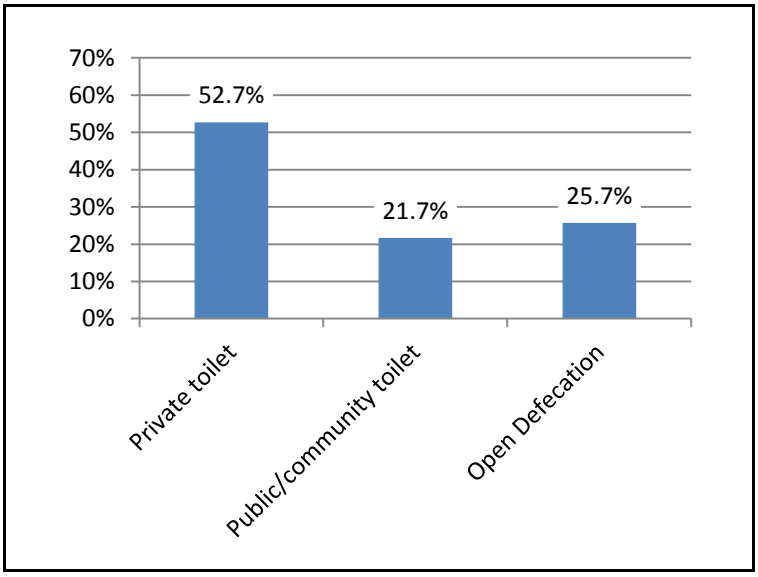
Because the survey drew respondents from low resource communities in two different cities in Gujarat, identifying their distinct characteristics allows for additional insight into heterogeneity that may persist by location. T-test comparisons of means among survey respondents from communities of Ahmedabad and Vadodara were roughly of similar age and reported BPL status, with statistically significant higher head of HH literacy levels in Vadodara (see Table B-2 in the appendix). However, when examining HH assets, respondents from Vadodara report significantly higher levels of ownership of luxury items, such as televisions, satellite dishes, and automobiles. Furthermore, ownership of other environmental health technologies (e.g., mosquito nets, LPG stoves, water treatment technology)is also significantly higher (p=.01) among residents of Vadodara. The notable differences in asset ownership in Vadodara may suggest higher wealth among HHs, and could additionally signal that Vadodara respondents are more experienced or aware of the benefits of technologies that decrease environmental health risk.

4.2 Current Sanitation: Beliefs, Behaviors, and Preferences

Of the 227 survey respondents, approximately half use private toilets as their primary sanitation facility, while one-quarter primarily rely on open defecation (OD), and the remaining 22% use public toilets (see Figure 1 & Table 3). These overall proportions roughly correspond with the distribution of sanitation infrastructure found in recent Gujarat-wide assessments of slum communities.[9]

However, these distributions varied drastically across the sample cities (see Table B-2 in the appendix). Participants from Vadodara were far more likely to rely on private facilities than those in Ahmedabad, who relied most frequently on public facilities. Reliance on OD is relatively similar across the two cities. As expected, given the high costs of private HH latrines, high asset count HH in the sample, (as defined by owning seven or more of twelve surveyed assets), were more likely to rely on private facilities, as were HH where heads of HHs had completed at least a primary education. Notably, respondents from HHs with low education or low asset counts were more likely to practice OD than use public facilities.

Figure 1: Primary Sanitation Facility—Survey Data



[9]A 2009 survey of sanitation conditions in Gujarat slums finds that approximately 31.7% of households rely on open defecation.
http://www.pas.org.in/Portal/document/ResourcesFiles/Water%20Supply%20%20&%20Sanitation%20in%20Slums,%20June%202011.pdf

Table 3: Primary Sanitation Facility by Sample Subset (Source: Survey Data)

	N	Private Toilet	Public/ Community Toilet	Open Defecation (OD)
Male	106	60%	20.0%	20.0%
Female	120	46.7%	23.3%	30.0%
Less than age 30	71	60%	11.4%	28.5%
Greater than age 30	156	49.4%	26.3%	24.4%
Head of household (HH) has completed min. primary education	157	64.9%	20.4%	14.7%
Head of HH did not complete primary education	69	24.6%	24.6%	50.7%
Ahmedabad	112	35.7%	41.1%	23.2%
Vadodara	114	69.3%	2.6%	28.1%
Low asset HH*	104	24.0%	34.6%	41.3%
High asset HH*	122	77.1%	10.7%	12.3%
Full sample	226	52.7%	21.7%	25.7%

* Note: Households are defined by whether they own greater than six ("high") or six or fewer ("low") HH assets from a list of twelve.

More male respondents from the sample reported using private toilets than female respondents, as were respondents under age 30. Only 11% of respondents under age 30 reported depending primarily on public facilities, compared to nearly half of respondents over age 30. Respondents with higher levels of education and higher income rely on private toilets, while lower levels of household wealth report relying on public/community toilets and open defecation.

4.2.1 Private Facilities

Summary of Conditions:

- **Average construction costs:** Rs. 10,005 (US $165) (Source: Survey)[10]
- **Average monthly costs on use or maintenance:** Rs. 242 (US $4) (Source: Survey)
- **Attitudes toward private toilets:** Private toilets are convenient and safe facilities, but entail expensive construction with limited government support. Several FGD participants reported malfunction of their toilets being common. Those without private toilets sometimes had small washing areas ("MORIs") that they used for urination at home, supplementing the public facilities that were used primarily for defecation.

Private facilities were generally preferred to other sanitation options, and focus group discussions suggest that this is based on associations with convenience, safety, and privacy. Participants noted that private toilets offer convenience and security during nighttime, especially for women and the elderly.

[10] Survey respondents were asked to approximate total construction costs for their toilet, regardless of government subsidy or assistance. Actual payments by households may have been lower depending on participation in these programs.

Private toilet owners' attitudes toward the required upkeep of private facilities suggest that users are willing to clean and maintain the system because they feel ownership over it.

The costs associated with private toilet ownership, summarized in Table 4, indicate that households that own private toilets face a wide range of costs (including initial costs and operation and maintenance expenditures). Survey participants responded that, on average, households spend Rs. 242 (approx. US $4) per month on private toilet maintenance and over Rs. 10,000 (approx. US $165) on initial construction (costs were reported slightly lower in FGDs.) Additionally, a very small segment of survey respondents reported receiving government or NGO assistance for toilet construction. Individuals from focus groups mentioned restrictions and conditions in government programs as a constraint to private toilet ownership. Those receiving government support reported contributing between 500 and 2000 rupees towards the toilet, compared to those without support who reported paying up to 15,000 rupees for construction.

Table 4: Costs and Assistance Related to Private Toilets (Source: Survey Data)

Variable	N	Mean	Std. Dev.	Min	Max
Household (HH) expenditure on use and maintenance of toilet, past 30 days (Rs.)	112	241.7	400	0	3000
HH expenditure on toilet construction (Rs.)	75	10005.3	12333	0	70000
HHs receiving government/NGO assistance with toilet construction (materials or payment)	92	9%	0	0	1

A regression model predicting primary private toilet use (Table 5, model 1) finds levels of education and wealth[11] as significant factors. The results indicate a highly significant positive association with household wealth and a negative correlation with head of household illiteracy, indicating that individuals with higher household wealth and higher levels of education may be more likely to have or primarily use a private toilet.

[11] In this model, the number of HH assets is a continuous variable and functions as a proxy for household wealth. Survey respondents marked which of twelve possible assets (e.g. auto, TV, refrigerator) they owned.

Table 5: Average Marginal Effects: Correlates of Use by Sanitation Facility (OD, Community/Public, Private Toilets) (Source: Survey Data)

	(1) Private Toilet (primary)	(2) Open Defecation (OD) (primary)	(3) OD (often/ sometimes)	(4) Community/ Public Toilet (primary)
Head of household (HH) is illiterate	−1.40** (0.71)	0.55 (0.56)	0.52 (0.62)	0.17 (0.66)
Head of HH has at least primary education	0.060 (0.57)	−0.96* (0.56)	−0.75 (0.51)	0.84 (0.56)
Number of HH assets (wealth proxy)	0.57*** (0.15)	−0.36*** (0.12)	−0.37*** (0.12)	−0.27** (0.12)
HH is not native resident of city	0.74 (0.49)	0.049 (0.44)	−0.19 (0.41)	−0.48 (0.52)
Below poverty line (BPL) cardholder	0.29 (0.39)	−0.43 (0.42)	−0.071 (0.37)	−0.026 (0.42)
Female head of HH	0.37 (0.70)	−0.31 (0.62)	−0.12 (0.52)	−0.34 (0.70)
Female respondent	−0.76** (0.38)	0.58 (0.37)	0.091 (0.33)	0.29 (0.38)
HH owns mosquito net/coil	0.68 (0.46)	−0.38 (0.52)	−0.14 (0.41)	−0.47 (0.50)
HH does not treat drinking water	−0.37 (0.60)	1.05** (0.51)	0.60 (0.54)	−1.11* (0.65)
HH owns liquid propane gas (LPG) stove	−0.087 (0.55)	0.56 (0.58)	0.33 (0.49)	−0.67 (0.54)
Constant	−3.38*** (0.87)	0.97 (0.70)	2.52*** (0.72)	0.25 (0.69)
Observations	218	218	218	218
R-squared	0.408	0.269	0.267	0.138
Robust standard errors in parentheses			*** p<0.01, ** p<0.05, * p<0.1	

Private toilet ownership results interpreted with insight from FGDs, suggest that, in some HHs, there are separate facilities for urination and defecation, a potentially important distinction of private toilet use and ownership. Many FGD participants reported owning bathroom facilities ("MORIs") that are used for bathing, cleaning, and urination, but may not be used for defecation. Some respondents reported that, if using their private facilities for urination, public toilets were their primary facility for defecation as noted in Table 6. This distinction in uses is important in both defining sanitation practices for future data collection, as well as understanding the costs that some private toilet owners still face.

Table 6: Frequency of Open Defecation by Primary Toilet Facility Use (Source: Survey Data)

	Never/Rarely	Sometimes	Regularly
Private Toilet	85.7%	5.9%	8.4%
Public Toilet	36%	10%	54%

4.2.2 Open Defecation

Summary of Conditions:

- **Average distance (time):** Average 10–20 minutes, maximum reported ~1 hour (Source: FGD)
- **Monetary cost:** Free
- **Attitudes toward open defecation:** Most affordable sanitation option, but low levels of hygiene/cleanliness, particularly during floods in monsoon season. Lack of gender segregation and longer distances pose time, privacy, and safety-related challenges for women. No available provisions for water, handwashing, or menstrual hygiene management (MHM). High awareness of associated disease and hygiene issues among focus groups.

Among survey respondents, OD is a common practice, even among those with access to and primary use of other sanitation facilities. As shown in Table 6, 54% of survey respondents that report primary use of public toilets and 8.4% that primarily use private toilets report practicing OD sometimes or regularly. Preliminary regression findings (Table 5, models 2 and 3) indicate that such behavior is strongly correlated with households with low asset count and those that do not regularly treat drinking water. This suggests that HHs that rely on OD may not have the financial ability or health awareness to switch to improved sanitation facilities.

Focus group participants identified few benefits to OD; however, the few features perceived as positive were reported as such in comparison to public facilities. Participants stated that OD allows users access to 'fresh air,' relative to enclosed facilities. OD is more affordable than pay-per-use public toilets and, more commonly noted among men, offers them the chance to socialize.

Demographic-specific Concerns:

Women**:** Female focus group participants identified issues with privacy and safety in OD sites. Women mentioned waiting to defecate if men were present, having to rise early to avoid men and crowds, and having to travel in groups or to closer, less private sites for safety.

Children**:** OD appears to be a common practice for children, though locations vary from directly outside the home to OD fields. Often, girls must be accompanied to OD sites. Some disposal of children's feces may be seen to pose an environmental health concern, as over one-third of primary-OD households with children report throwing their feces 'anywhere outside the home' (see Table 7).

Table 7: Disposal of Child Feces for OD Households with Children (Source: Survey Data)

	N	Percent
Thrown anywhere outside home	15	35.7%
Thrown in sewer/garbage dump outside	18	42.8%
Washed down bathroom/sink at home	9	21.4%

4.2.3 Public Toilets

Summary of Conditions:

- **Average distance (time):** 5–15 minutes (source: survey data)
- **Average monetary cost:** Rs. 2–5 (source: survey data)
- **Average wait times:** 10–25 minutes (source: FGDs)
- **Attitudes toward public toilets:** Gender segregation is broadly preferred. Handwashing provisions are available in ~50% of locations used by focus group participants; soap available in 50% of those facilities. Most facilities are pay-per-use; some collect monthly fees; urination is often free of charge. Features such as poor cleanliness and maintenance are common dislikes.

Responses from focus groups indicate that public toilet users were generally content with the fees charged for public toilets. Facilities seemed to be more consistently used for defecation; several participants reported urinating at home in a MORI or in open fields, particularly if their public facilities charged for urination (see Table 8).

Table 8: Reported Costs of Public Toilets (Rs.) (Source: Survey Data)

	N	Mean	Std Dev	Min	Max
Household (HH) spending on community toilet (past 30 days)	93	73	122.9	0	500
Time spent walking to community toilet (minutes)	89	7.1	5.4	0	30

Access challenges and poor cleanliness were the most common negative qualities of public toilet use. Restrictive hours, long distances, and wait times for toilet access create significant challenges, forcing some women to openly defecate, despite the availability of toilets. Dirty and soiled spaces, bad odor, and drainage overflows were frequently cited as unappealing attributes of public facilities. Safety concerns at public facilities presented additional challenges for women and girls.

Survey respondents rated public facilities on a five point poor-to-excellent scale and suggest that barriers to access and perception of the conditions of public facilities may motivate the behavior of nonpublic toilet users—those with access to public but not private toilets (see Table 9). Of the 52 respondents (22%) of the sample that had access to public facilities, 40 people (77%) used them frequently and the remainder (23%) did not use them at all.

In this sample, factors like privacy, cleanliness, smell, flushing system, and distance/time traveled from home are significant in framing perceptions of public toilets. Regular public toilet users lived closer, on

average, to public facilities than nonusers, and tended to rate them more highly than nonusers. For the few nonusers with access to public facilities, the poorer access and perception of public facilities may be driving the decision to not use them.

Table 9: Public Toilet Ratings by Nonusers and Regular Users, Subsample of Users with Access to Public Toilets but without Private Toilets (Source: Survey Data)

Feature	Nonusers		Regular users		Mean Diff
	N	Mean	N	Mean	
Distance from home	12	2.417	40	3.625	−1.208**
Privacy during use	11	1.909	40	3.225	−1.316***
Cleanliness	12	2.25	40	3.275	−1.025*
Smell	12	1.833	40	2.675	−0.842*
Flushing system	12	2	39	3.128	−1.128**
Availability of anal cleaning provisions	12	2.667	40	3.35	−0.683
Handwashing facility	12	2.75	36	3.028	−0.278
Attendant/caretaker	12	2.833	37	3.514	−0.68
Lighting in toilet	12	3.083	39	3.333	−0.25

*: p= 0.10, **: p = 0.05, ***: p = 0.01. Note: Ratings are on a scale of 1 (poor) to 5 (excellent).

As with private toilets, regression results (Table 5, model 4) indicate that HH wealth is a strong determinant of public toilet use. The negative correlation suggests that lower wealth HHs may rely on public sanitation sites due to their comparatively low costs of use. However, the significance of factors such as education and drinking water treatment suggests that greater awareness or knowledge of health issues may lead HHs to choose public facilities instead of OD sites.

4.3 Ideal Public Toilet: Preferences

Descriptions of ideal sanitation facilities offered by the focus groups generally centered on cleanliness, access, and convenience features, including MHM disposal for women. Most respondents tended to be conservative in their conceptions of 'ideal sanitation' facilities; according to one respondent, "It is not a picnic spot where we would desire some luxury."

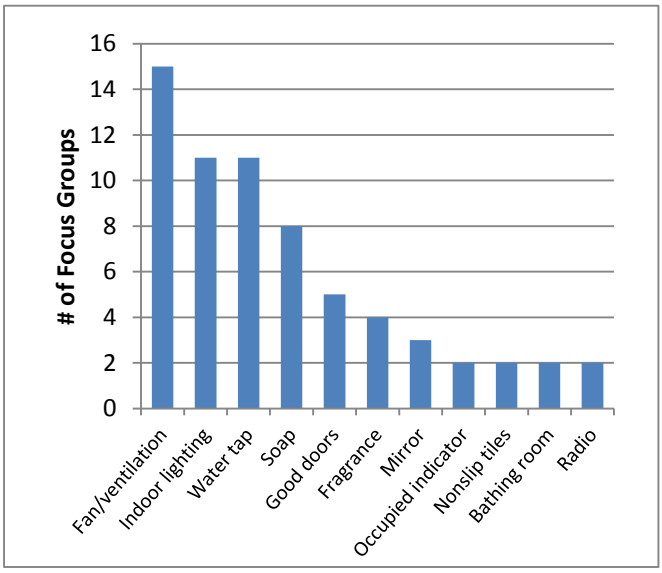
Water supply emerged as a frequent request among many of the focus groups. Water was often restated several times in a conversation, or considered "a must." The language and frequency of this suggestion imply that water supply may be a critical factor for adoption. Further research is necessary to assess existing provisions and determine attitudes toward water at sanitation sites.

Cleanliness emerged as the most common theme. Respondents wanted well-kept and functioning facilities (e.g., with no overflow of drainage), and proper ventilation. Out of 23 focus groups, 15 mentioned some form of ventilation, such as an exhaust fan or window, though some were concerned about privacy and security with the latter. Ventilation appears to have been considered a solution for bad smell, stuffiness, or sometimes heat. Water supply and soap were also mentioned by nearly half of the focus groups for cleanliness and convenience.

Access-related improvements were suggested across focus groups, but particularly among women. Users frequently mentioned indoor lighting provisions for use at night, longer open hours, larger stalls and seats for heavier users (though this conflicted with later suggestions to reduce the size of the RTI system), and poster guidelines, as noted in Figure 2.

Other considerations mentioned by two or more focus groups included mirrors (though some believed this might increase wait times), well-made doors, pleasant fragrance, 'occupied' indicators, and nonslip flooring. Most focus groups also reiterated the need for menstrual disposal bins for women.

Figure 2: Suggested Features by Frequency of Mention



Source: Focus Group Data, n=32

Focus group and survey findings also revealed non-ideal aspects of sanitation. Gender-segregation was highlighted as a chief requirement at sanitation sites. Focus group participated stated that use of mixed-gender sanitation facilities was associated with feelings of shame. When asked specifically if they would use unisex facilities, most questioned respondents answered no. However, discussions also suggest that private or family latrines may be an exception to the widely held, gender-specific facility preference.

Additional negative aspects included safety and privacy concerns, largely in relation to women and girls. Focus group discussions provided anecdotal evidence of safety concerns associated with open defecation or traveling long distances to use a toilet. Privacy was discussed most commonly for girls and women, but is an aspiration shared by both men and women respondents.

Focus groups discussed willingness to pay for an 'ideal sanitation system,' which varied for one-time investment and maintenance fees. For a pay-per-use ideal system, willingness to pay (WTP) interestingly stayed within the range of fees of existing systems: 2–5 Rs. More respondents preferred pay-per-use fee structures than monthly payments, and some feedback suggested the expectation of free usage for urination.

The survey posed a hypothetical scenario in which respondents were told of an improved 'ideal' public toilet, supported by a local NGO, and asked how much they were willing to pay in contribution to the initial capital costs and ongoing operation and maintenance costs each month. The improved public toilet would be intended for use by the entire family and installed within the next 6 months. Table 10 reports the stated estimate of willingness to pay for this new toilet, though only offers a preliminary estimate of willingness to pay due to the small sample size and exploratory nature of the study.

Table 10: Willingness to Pay for an Improved Public Toilet (Source: Survey Data)

Willingness to Pay	Mean	N	Standard Error	Median	Min	Max
Household (HH) willingness to pay (WTP) for initial start-up of community toilet (whole family)	2013	187	5008.6	1000	0	50000
HH WTP for maintenance of community toilet (whole family)	102	224	107.7	85	0	600

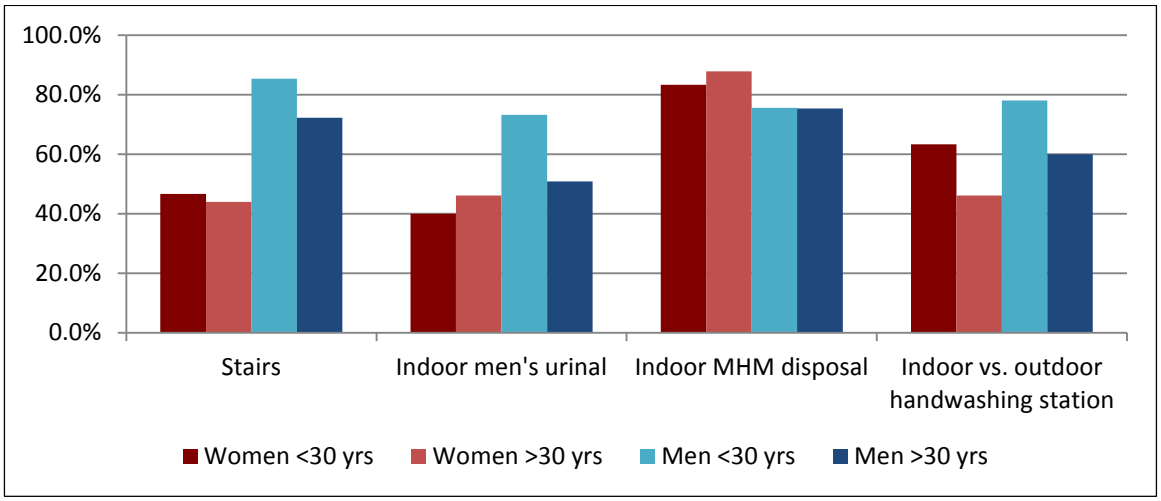
Overall, many survey respondents were willing to contribute something to the hypothetical toilet project, but differences emerged by types of current sanitation facilities. About 4% of the sample refused to pay any amount for construction under the scenario; however, when not including those respondents who already own a private toilet (n=118), less than 2% are unwilling to pay. Interestingly, approximately 75% of private toilet owners are willing to pay something for public toilets, with a mean contribution of Rs. 3205 for initial costs (n=108) and Rs. 106 in monthly maintenance fees (n=109). This suggests that community or public toilets may function as a complement to private toilets and fulfill additional sanitation needs outside the home.

Notably, all respondents (100%) who use public toilets as their primary sanitation facility were willing to contribute something to the hypothetical toilet; on average, this group offered Rs. 909 in initial costs and Rs. 99 in monthly maintenance costs. Finally, 81% of respondents relying on OD primarily were willing to contribute and reported WTP for the toilet at Rs. 1099 in initial costs (n=51) and Rs. 94 monthly (n=56).

4.3 RTI System: Preferences

Overall, response to the RTI system was positive. Survey participants from Ahmedabad and Vadodara were initially shown a video of the RTI toilet highlighting its components and processes; participants from Vadodara were then additionally shown the RTI prototype and allowed to flush and ask questions about the system. Respondents were particularly enthusiastic about the combustion process and appreciative of the unit's apparent cleanliness and energy efficiency. The following discussion of features is based primarily on the survey data, corroborated with supplemental and explanatory details from focus groups. A quantitative summary of users' reactions to RTI system attributes is included in the appendix (see Table B-3). Figure 3 charts feedback on structural preferences for the user interface.

Figure 3. Structural Addition Preferences



Source: Survey

Stairs: Interestingly, preferences to elevation of the RTI unit varied across gender, but not age. Slightly more women preferred no stairs (55%), while most men preferred some stairs (75%). Those preferring no stairs, however, generally found it 'very important.' Preliminary regression results suggest that OD users in particular tend to prefer stairs, a finding consistent with focus group discussions. Stairs "help to avoid from mud" and during monsoon season, "are required due to overflow of water." The majority of focus groups across age and gender said they preferred two to three steps but would accept up to five steps, and recommended additional handles to support the elderly. Additional concerns regarding disabled access were discussed.

Urinal: The survey asked about designated men's urinals inside the toilet, eliciting contrasting answers by gender, as might be expected. Most young men preferred inclusion of the urinal (75%), though only half felt that it was 'very important.' Women slightly preferred no urinal (55%), and older men were divided. Women in focus groups generally felt that indoor urinals were unnecessary and would consume more time, but were accepting of separate facilities outside. Older-aged focus groups also supported outdoor urinals and suggested separate, lower fee structures for urinal use. Among some male discussions, concern was raised about charging a price for urinal use, as many male participants were not accustomed to paying for urinals.

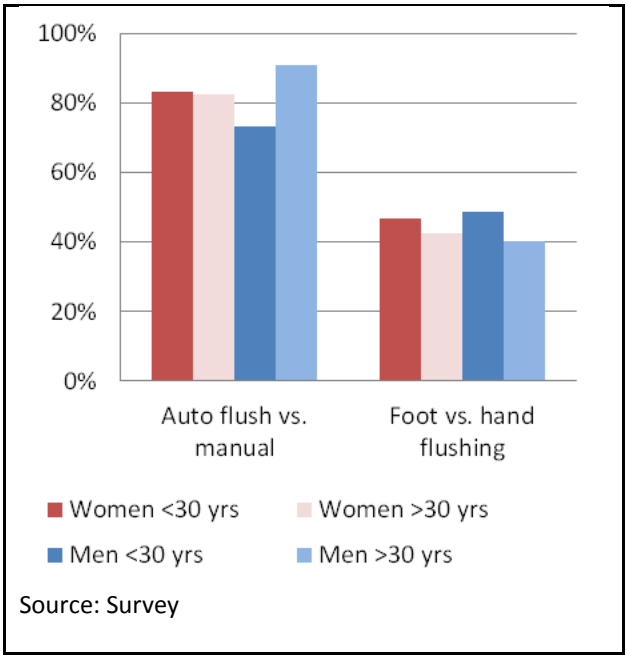
Menstrual Hygiene: The majority of male and female survey respondents (80%) strongly preferred disposal bins for MHM inside the toilet, as opposed to no provisions at all. However, focus group discussions were particularly important for identifying a wide range of beliefs and practices regarding the method of menstrual product disposal. Firstly, many women (older) used cloths for MHM, often reusing cloths after cleaning and drying. Younger women tended to use sanitary napkins and disposed of them after a single use. Secondly, when asked about reactions to different disposal methods, such as burning (which may have significant implications for the system's combustion system in-place), many women were accustomed to disposing of menstrual materials in the trash but took no issue with burning their sanitary materials; as one respondent put it: "it is better because it does not spread dirt." Some women, however, felt strongly that menstrual hygiene products not be burned. The women

questioned also had positive responses to sanitary napkin vending machines, particularly for use by young girls.

Handwashing: The survey asked respondents whether they preferred handwashing facilities inside or outside the toilet unit. Respondents across gender, age, and socioeconomic status tended to prefer indoor washing stations (60%), except for women over 30 who slightly preferred outdoor stations. Responses in focus groups were mixed. Those wanting an indoor station expressed concern for maintenance and cleanliness and a desire to complete sanitation inside (as "dirtiness never comes out from the toilet"). Those who preferred outdoor stations cited their interest in using them as public basins and note that use of outdoor stations was habitual for many.

Flush: Approximately 80% of respondents across age, gender, and socioeconomic status preferred an automatic flush mechanism to manual pouring, as shown in Figure 4. Preliminary regression findings indicate that primary OD users also tend to prefer auto-flush.

Figure 4. Flush Preferences

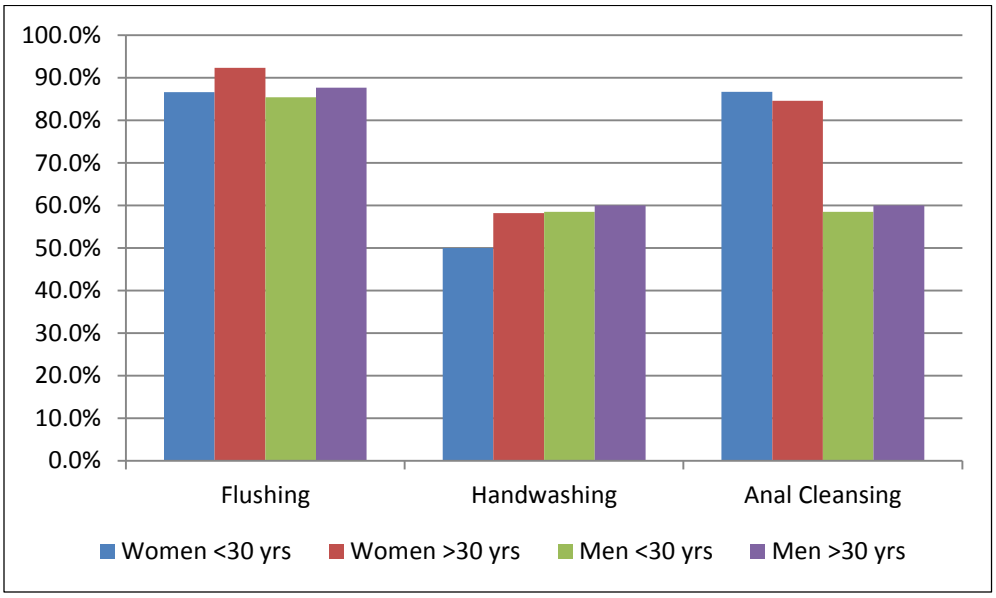


Source: Survey

Survey data suggests that reactions were mixed on hand- vs. foot-operated flushing. In the survey data, slightly more respondents (55%) preferred hand flushing; focus group responses were similarly split. Older men and women who preferred hand-pedaling were likely to cite it as 'very important,' in contrast with other groups who were more ambivalent. Respondents from focus groups generally accepted the foot pedal for themselves, but expressed concern for children and the elderly who could slip or find the foot pedal difficult to use. One discussion of respondents in the oldest age category preferred the foot pedal, however, because it would not require them to bend for usage. Collected anecdotes suggest that the foot pedal could be improved by bringing it closer to the toilet seat, making the lever smoother, and decreasing its height. There were fewer concerns about the hand pedal, as many stated they were already accustomed to it.

Water Reuse: Figure 5 presents survey data on water reuse preferences. An overwhelming majority of respondents across gender, age, and socioeconomic status (80–90%) preferred using treated waste water for flushing and anal cleansing. Preferences toward reuse for handwashing were mixed, however, with a slight preference for treated water (55%) over fresh tap water. Responses from the focus groups were often conflicted, as respondents generally appreciated the idea of water conservation, but many took issue with the principle of washing with flushed water or disliked the color and smell of recycled water. Two focus groups indicated that they would be willing to pay higher fees for a fresh water supply for handwashing. Water reuse may be a contentious issue and requires further investigation, as over 75% of survey respondents from each age/gender group stated their own preference as 'very important.' Focus groups were also highly resistant to substituting spray-cleaning provisions for anal cleansing with toilet paper.

Figure 5. Water Reuse Preferences



Source: Survey

Sit Position: Survey respondents generally preferred a squat position to a seated position (80%), though older men and women who preferred sitting tended to find it 'very important.' Focus groups similarly stated a preference for squat-style toilets, but wanted one or two sit-style toilets for children and the elderly. Many respondents were more comfortable with squat-style toilets common in India and believed the Western-style pedestal toilet seats would require more cleaning. Some older respondents believed the addition of handrails could help the elderly or those with knee problems with squatting.

Location: Reactions were split on wanting the RTI toilet as a private vs. public toilet. Poorer and less educated respondents held a slight preference for the public toilet (60%). Size appeared to be a determinant in the FGDs, as some respondents said they might consider a smaller design for their homes. One group from Ahmedabad also repeatedly expressed concerns about street space when discussing implementation as a public toilet.

5. Findings, Recommendations, and Conclusions

The results of June 2014 user studies provide valuable insights into individuals' current sanitation behaviors, beliefs, and preferences, and their preferences regarding ideal sanitation system attributes and preferences related to the RTI system. These findings, summarized in Table 11, will directly affect decisions made regarding adjustments to the user interface for the Alpha prototype being designed in the short-term (see Table 12) and will inform system development in the long-term through identifying important features that may affect user adoption. Table 13 summarizes key areas that may have adoption implications and thus should be further explored in order to better understand user preferences.

Table 11: Summary of User Input/Feedback on RTI Prototype Features (June 2014)

Topic	Observation
Overall reactions to RTI system	• Perception of high acceptance of RTI system in participants' communities • System perceived as safe
Highly favored features	• On-site waste treatment; liquid reuse (e.g., flush, anal cleansing); solid waste combustion • Decreased community drainage problems • Waste-driven energy generation to power the system; water conservation • Potential mobility of unit
Gender- and demographic-specific considerations	• Strong preference for separate facilities for men and women • Support for urinal; unclear preference for location (inside/outside) and separate pricing • Interest in and evidence of complex preferences related to menstrual hygiene accommodations (e.g., pad disposal, pad vending machine) • Interest in adding handrails and decreasing number of stairs for elderly/disabled access
Toilet interface	• Preference for squat option over seated toilet interface • Strong preference for anal cleansing by water; nozzle or bucket method (as opposed to by paper)
Flush mechanism	• Preference for automated flush (as opposed to manual powered) • Mixed preferences for flush mechanism (hand vs. foot operated)
Cabin and exterior features	• Preference for internal handwashing station • Exterior features desired include door lock; good lighting inside/outside unit
Water reuse	• High acceptance of reuse of water for flushing • Slight majority accept using recycled water for anal cleansing • Preference for water availability for washing • Mixed preferences for use of reuse water for handwashing • Respondents attach strong importance to issue of water reuse for handwashing, despite a lack of clear preference favoring or disfavoring reuse for this purpose
Willingness to pay (WTP)	• Initial evidence of demand and willingness to contribute for initial costs
Topic	• Observation

Table 12: Recommendations for Potential System Adaptation

Data Collection Findings	Recommendation for Potential System Adaptation
Gender-separated sanitation practices	Clearly identify separate toilet units for men and women; incorporate gender-specific unit attributes (e.g., urinal, menstrual hygiene management [MHM] bin)
Auto-flush preference	Retain automatic flush system in design
Squat sitting position	Retain design with squat plate
Menstrual disposal bin (presence)	Develop plan for menstrual disposal and (potential) processing menstrual hygiene products in RTI system

Table 13: Recommendations for Future Data Collection

Data Collection Findings	Recommendation for Future Data Collection
Current Sanitation Conditions	
Barriers to use of public toilets: access, location, safety	Explore conceptual barriers to use and practical, system-based barriers
Ideal Sanitation Attributes	
Positive attributes: cleanliness, ventilation	Explore concrete, physical attributes that achieve attractive qualities in system
Water supply	Develop understanding of water use and reuse at sanitation facility and quality of acceptability (e.g., bathing, washing clothes), quantity used, and potential willingness to pay (WTP) for supply; future data collection may focus on issues of water quality preferences and user valuation of water saving
RTI System Characteristics	
WTP	Characterize demand in the context of real barriers to investment
Menstrual disposal (method); women-specific	Clearly define possible disposal methods and assess user opinions and cultural acceptability; further exploration is needed, and specifically, exploration of the acceptability of use of disposal chute and method of disposal; several potential options to experiment with acceptability include building a mock chute, and addition of a mechanism for shredding and burning
Water reuse (e.g., flushing, anal cleansing, handwashing)	Develop understanding of identified concerns regarding use of system's recycled water; build further understanding about attitudes toward behaviors appropriate for water reuse (e.g., handwashing)
Flush pedal operation (hand/foot)	Refine knowledge of preferences (e.g., height, ease of use, best placement) of flush mechanism
Urinal location (inside/outside); male-specific	Develop understanding of preferences and role of monetary (WTP) constraints in relation to urinal addition; future data collection may include experimentation of urinal location and pricing
Stairs; handrail (elderly/disabled)	Understand challenges as they relate to vulnerable demographics suggested in focus group discussions (FGDs)
Cabin size	Build understanding of how users value cabin space, preferences related to current cabin size of prototype

5.1 Forthcoming Data Collection Planned (Q4 2014 and Q1 2015)

To support the development of a reinvented toilet that is desirable, cost-effective, and sustainable, RTI plans to continue to conduct field-based user studies that are designed to be iterative and provide continuous feedback into RTI's technology development and performance testing teams. Field study cycles are designed to occur quarterly in 2014 and 2015. Recommendations for the next round of field data collection include FGDs framed around the following topics in order to gain additional insights on preferences (likely to be conducted in Q4 2015).

- **Water reuse**.
- **MHM**. Further exploration of the acceptability of disposal methods may be included in FGDs and surveys. Several options include experimentation with a mock chute, and addition of a mechanism for shredding and burning.
- **User interface cabin size**.
- **Flush mechanism**. Prototype adjustments will vary placement and location of the flush mechanism for additional feedback.
- **Handrails**.
- **Urinal for men**.

Additional data collection through the implementation of an HH survey, likely in Q1 2015, will provide an opportunity for larger and randomized sampling, as well as more in-depth exploration of several topics. Recommendations to be considered in an HH survey include the following:

- **User valuation of RTI system features**. Developing an understanding of user prioritization of RTI features may help the system evolve for optimal user adoption.
- **Public toilets and transitions from OD**. Barriers to using public toilets, and concerns about transitioning from OD to use of shared toilets, could be explored.
- **MHM**.
- **Water use and supply**. Detailed understanding of water use and preferences may inform prototype development regarding additional bathing or washing features.
- **Current knowledge regarding sanitation practices and sanitation-related illness**.
- **Behaviors related to water use and sanitation**.

Appendix A

A.1 Development of Data Collection Materials

In April and May, RTI and NEERMAN staff collaborated on the design and preparation of the focus group discussion (FGD) guide, the questionnaire, and data collection procedures and training documents. The FGD guide and the questionnaire were both shared with the Self Employed Women's Association (SEWA) prior to conducting the user sessions. The final translation of both instruments from English to Gujarati was completed by the Network for Engineering, Economics, Research, and Management (NEERMAN). The questionnaire was administered in Gujarati, and the focus groups were conducted primarily in Gujarati.

A.2 Participant Recruitment and Incentives

SEWA recruited a convenience sample of participants from populations residing in low resource areas in Ahmedabad and Vadodara. Participants were drawn from slum communities where SEWA has active relationships and targeted Hindu and Muslim neighborhoods in both cities. To generate interest in participation, SEWA staff in the chosen slum communities distributed a flyer and disseminated information through small gatherings within the community. Community residents interested in participating were identified, clustered by age and gender, and scheduled for designated times. Participation was voluntary. Each respondent received a lunch pail as a gift after his or her participation.

A.3 Training

NEERMAN led the training of data collection teams on June 6, 7, and 9, 2014. Training focused on orientation and testing of the questionnaire forms, questionnaire and FGD administration best practices, contingency measures, and informed consent. Field supervisors were additionally trained for managing daily logs, distributing and collecting informed consent forms and maintaining confidentiality, securing completed survey forms, and communication with partners. The training sessions included classroom discussions, question-and-answer sessions, mock interviews, and practice in focus group administration.

A.4 Research Ethics

Throughout the design and data collection, NEERMAN, SEWA, and RTI adhered to strict ethical guidelines to respect the rights of research participants and to protect respondent confidentiality. RTI's Institutional Review Board (IRB) reviewed and approved these activities, including both RTI and FIRMENICH's data collection instruments and procedural documents, prior to data collection.

During interviewer training, individuals were trained to properly administer an informed consent to a potential respondent. Key components of the informed consent included a description of the study procedures, the right to refuse to participate, and a description of how respondent confidentiality is maintained.

Before beginning the questionnaire, interviewers read the informed consent script to each participant and answered any questions from the respondent about the process. Participants and interviewers then signed the consent forms. Interviewers did not record respondents' names or other information that

could potentially identify a respondent. Interviewers also kept completed surveys, consent forms, and FGD notes and tape recordings in a secure location during fieldwork.

A.5 Staffing

The fieldwork started in Ahmedabad on June 10, 2014, and ended in Vadodara on June 19, 2014. All field study teams were experienced managers and facilitators of qualitative and quantitative data collection. NEERMAN fielded one male and one female facilitator for questionnaire administration and FGDs, each of whom were accompanied by one note-taker and one enumerator. Both teams were overseen by one supervisor. A translator was generally available to translate Gujarati to English for international researchers on the team. SEWA staff were present to manage the flow of participants, assist in managing FGDs, and provide participants with snacks at the end of the sessions. L&T Engineering personnel were available on site to support operation of the RTI system and support meetings and logistics.

A.5.1 Quality Assurance

The study used several methods to ensure the quality of data collection, including field observations, confidentiality, and survey review and storage. Supervisors conducted on-site observations of processes and collected completed questionnaires for review and identification of problems. At the end of each day, forms, notes, and transcripts were reviewed and stored safely. NEERMAN regularly convened supervisors and team members to identify and resolve issues and conducted random spot checks during data entry. RTI, NEERMAN, and SEWA staff routinely reviewed data collection logistics and procedures.

Appendix B

Table B-1: FGD Topics, Demographics, and Location

	Location	Demographic	FGD topic	Survey
FGD 1	Ahmedabad	Women 18–30 Yrs	Community Toilets	No
FGD 2	Ahmedabad	Men 18–30 Yrs	Community Toilets	No
FGD 3	Ahmedabad	Women 18–30 Yrs	Technology	No
FGD 4	Ahmedabad	Men 18–30 Yrs	Technology	No
FGD 5	Ahmedabad	Women 31–54 Yrs	Hygiene	No
FGD 6	Ahmedabad	Men 31–54 Yrs	Hygiene	No
FGD 7	Ahmedabad	Women 31–54 Yrs	Technology	No
FGD 8	Ahmedabad	Men 31–54 Yrs	Technology	No
FGD 9	Ahmedabad	Men and Women 55–70 Yrs	Technology	No
FGD 10	Ahmedabad	Parents of u18 children	Technology	No
FGD 11	Ahmedabad	Men and Women 55–70 Yrs	Defecation Behavior	No
FGD 12	Ahmedabad	Parents of u18 children	Defecation Behavior	No
FGD 13	Ahmedabad	Women 18–30 Yrs	Hygiene	Yes
FGD 14	Ahmedabad	Men 18–30 Yrs	Hygiene	Yes
FGD 15	Ahmedabad	Women 18–30 Yrs	Defecation Behavior	Yes
FGD 16	Ahmedabad	Men 18–30 Yrs	Defecation Behavior	Yes
FGD 17	Ahmedabad	Women 31–54 Yrs	Community Toilets	Yes
FGD 18	Ahmedabad	Men 31–54 Yrs	Community Toilets	Yes
FGD 19	Ahmedabad	Women 31–54 Yrs	Defecation Behavior	Yes
FGD 20	Ahmedabad	Men 31–54 Yrs	Defecation Behavior	Yes
FGD 21	Ahmedabad	Men and Women 55–70 Yrs	Community Toilets	Yes
FGD 22	Ahmedabad	Parents of u18 children	Community Toilets	Yes
FGD 23	Ahmedabad	Men and Women 55–70 Yrs	Hygiene	Yes
FGD 24	Ahmedabad	Parents of u18 children	Hygiene	Yes
FGD 25	Vadodara	Women 18–30 Yrs	Technology	Yes
FGD 26	Vadodara	Men 18–30 Yrs	Technology	Yes
FGD 27	Vadodara	Women 18–30 Yrs	Defecation Behavior + Hygiene	Yes
FGD 28	Vadodara	Men 18–30 Yrs	Hygiene	Yes
FGD 29	Vadodara	Women 31–54 Yrs	Technology	Yes
FGD 30	Vadodara	Men 31–54 Yrs	Technology	Yes
FGD 31	Vadodara	Women 31–54 Yrs	Community Toilets + Hygiene	Yes
FGD 32	Vadodara	Men 31–54 Yrs	Community Toilets + Hygiene	Yes
FGD 33	Vadodara	Men and Women 55–70 Yrs	Technology	Yes
FGD 34	Vadodara	Parents of u18 children	Technology	Yes
FGD 35	Vadodara	Men and Women 55–70 Yrs	Defecation Behavior + Community Toilets	Yes
FGD 36	Vadodara	Parents of u18 children	Defecation Behavior + Community Toilets	Yes

Table B-2: Independent Group T-Test by City

	Ahmedabad (mean)	Vadodara (mean)	T-statistic	P-value (two-tailed)
Respondent age	38.4	35.0	1.88	0.06
Migrant household	17.7%	21.9%	−0.80	0.43
Time living in community	27.1	22.2	2.43*	0.02
Head of household (HH) age	40.9	37.8	2.09*	0.04
Head of HH is illiterate	12.4%	23.7%	−2.23*	0.03
Head of HH has at least primary education	70.8%	67.5%	0.53	0.60
HH has below poverty level (BPL) card	29.2%	28.9%	0.04	0.97
HH owns home	69.0%	76.3%	−1.23	0.22
HH has electricity connection	92.9%	96.5%	−1.20	0.23
HH owns bicycle	47.3%	52.6%	−0.80	0.43
HH owns TV	63.7%	79.8%	−2.73**	0.01
HH owns mobile phone	86.7%	94.7%	−2.09*	0.04
HH owns liquid propane gas (LPG) stove	50.4%	69.3%	−2.94**	0.00
HH owns refrigerator	23.0%	43.0%	−3.26**	0.00
HH owns water filter	0.9%	7.9%	−2.60**	0.01
HH owns mosquito net	26.5%	48.2%	−3.45**	0.00
HH owns satellite dish	50.4%	75.4%	−4.02**	0.00

p-value: **= .01, *= .05

Table B-3. RTI System Preferences by Socio-Demographic

System Feature		Women				Men				Socio-economic Status		Head of Household Education	
		<30 yrs		>30 yrs		<30 yrs		>30 yrs		<7 assets (105)	>7 assets (122)	Less than primary school (70)	Greater than primary school (157)
		30	very important	-91	very important	-41	very important	-65	very important				
Flush	Auto	83.30%	72.00%	82.40%	61.30%	73.20%	76.70%	90.80%	64.40%	76.20%	89.30%	70.00%	89.20%
	Manual/pour	16.60%	60.00%	17.60%	43.75%	26.80%	36.40%	9.20%	33.30%	23..8%	10.70%	30.00%	10.80%
Flush pedal	Foot-operated	46.70%	57.10%	42.30%	53.50%	48.80%	50.00%	40.00%	53.90%	46.70%	44.30%	50.00%	43.30%
	Hand-operated	53.30%	56.20%	52.70%	70.80%	51.20%	66.70%	60.00%	79.40%	53.30%	55.80%	50.00%	56.70%
Sit position	sit	20.00%	50.00%	22.00%	80.00%	21.90%	33.30%	10.70%	71.40%	10.40%	25.40%	28.60%	25.50%
	squat	80.00%	75.00%	78.00%	74.60%	78.50%	65.60%	89.30%	72.40%	89.50%	74.60%	97.10%	74.50%
Location	Toilet in home	56.70%	58.80%	44.00%	60.00%	41.50%	70.60%	52.30%	79.40%	41.90%	52.40%	41.40%	50.30%
	Public toilet	43.30%	76.90%	56.00%	70.60%	58.50%	41.70%	47.70%	64.50%	58.10%	47.50%	58.60%	49.70%
Elevation	No stairs	53.30%	68.80%	56.00%	62.70%	14.60%	66.70%	27.70%	66.70%	34.30%	45.10%	41.40%	39.50%
	Stairs	46.70%	42.90%	44.00%	40.00%	85.40%	37.10%	72.30%	48.90%	65.70%	54.90%	58.60%	60.50%
Hand-washing	Outside toilet	36.60%	81.80%	53.90%	57.10%	22.00%	44.40%	40.00%	73.10%	42.90%	40.90%	41.40%	42.00%
	Inside toilet	63.30%	52.60%	46.20%	69.10%	78.10%	65.60%	60.00%	65.80%	57.10%	59.00%	58.60%	58.00%
Urinal	No urinal	60.00%	66.70%	53.90%	75.60%	26.80%	54.50%	49.30%	68.80%	50.50%	46.70%	37.10%	53.50%
	Urinal inside	40.00%	66.70%	46.10%	54.80%	73.20%	43.30%	50.80%	66.70%	49.50%	53.30%	62.90%	46.50%
Water reuse (flushing)	Fresh municipal water	13.30%	100.00%	76.90%	71.40%	14.60%	33.30%	12.30%	62.50%	15.20%	7.40%	10.00%	11.50%
	Treated waste water	86.60%	48.00%	92.30%	63.10%	85.40%	82.90%	87.70%	75.40%	84.80%	92.60%	90.00%	88.50%
Water reuse (hand-washing)	Fresh municipal water	50.00%	86.60%	41.70%	76.30%	41.40%	88.20%	40.00%	92.30%	45.70%	39.30%	47.10%	40.10%
	Treated waste water	50.00%	60.00%	58.20%	73.60%	58.50%	79.20%	60.00%	84.60%	54.20%	60.60%	52.90%	59.90%
Water reuse (anal cleaning)	Fresh municipal water	13.30%	75.00%	15.40%	71.40%	41.50%	75.00%	40.00%	64.30%	20.00%	15.60%	17.10%	17.80%
	Treated waste water	86.70%	65.40%	84.60%	66.20%	58.50%	81.80%	60.00%	78.40%	80.00%	84.40%	82.90%	82.10%
Menstrual hygiene	No bin	16.60%	60.00%	12.10%	36.30%	24.40%	66.70%	24.60%	28.60%	19.10%	18.00%	17.10%	19.10%
	Disposal bin inside	83.30%	79.10%	87.90%	77.50%	75.60%	74.20%	75.40%	65.30%	81.00%	82.00%	82.90%	80.90%