

A Gender Lens into Sanitation Technology Innovation

Myles Elledge¹; Alison Parker, Ph.D.²; Anju Toolaram, Ph.D.³; and Brian Stoner, Ph.D.⁴

Abstract: Innovators in the water and sanitation sector are focused on closing the sanitation gap in developing countries through innovation in technologies that enable waste treatment onsite. To ensure universal access, these technologies need to meet the practices and preferences of different genders. This paper uses an online survey and follow-up telephone interviews with technology developers and examined the different technology development processes through a gender lens. The paper also explores the influence of the composition of the research and development teams on gender considerations in the project because the water and sanitation technology world is often male-dominated. The majority of the teams incorporated gender considerations, although with limited depth. Teams designing user interfaces and toilet cabin stalls were most likely to integrate gender. Waste-processing technologies are often assumed to be neutral, not requiring gender considerations. Technology development teams were predominately male, although with some female representation; a few have female leaders. **DOI:** [10.1061/\(ASCE\)ME.1943-5479.0000775](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000775). This work is made available under the terms of the Creative Commons Attribution 4.0 International license, <http://creativecommons.org/licenses/by/4.0/>.

Introduction

An estimated 2.5 billion men, women, and children around the world do not have reliable access to basic sanitation services that ensure hygienic separation of human excreta from human contact (WHO 2017). In response to this challenge, global teams of innovators in the water and sanitation sector are focused on closing the sanitation gap in developing countries. This drive has international research teams developing radical new technologies that could revolutionize decentralized treatment approaches. However, even if a sanitation system uses technology that is proven to perform hygienic waste treatment, it still needs to be socially and culturally acceptable and dignified, as well as safe and convenient (Caruso et al. 2017). Sanitation programs are often implemented assuming no difference in gender, which can result in gender-specific failures (Dankelman et al. 2009). Men and women have unique physiologies, bodily functions, and preferences, which affect how they experience sanitation technologies (Fong et al. 1996; Dankelman et al. 2009; Tilley et al. 2013; IASC 2017).

Understanding and accounting for the needs of women and girls is particularly important. Women and girls are disproportionately impacted by the lack of safe sanitation coverage because it affects their daily activities, can lead to unsafe hygiene and illness, and contribute to absences from work and school (World Bank 2010; Wendland et al. 2012; Tilley et al. 2013; Van de Lande 2015). The feeling of security for women using a toilet is dependent on many factors including locations of the toilet, proximity of the

female toilets to male toilets, structural design of cabins, water supply, sanitary disposal units, adequacy of lighting, and presence of an appropriate caretaker, among other factors (Tilley et al. 2013; Kwiringira et al. 2014; Belur et al. 2017). Menstrual hygiene management (MHM) in particular is identified as an area where consideration for women is necessary and is often neglected or avoided due to cultural taboos (Van de Lande 2015). However, it is also imperative that the needs of men are not excluded; for example, they tend not to use smelly pit latrines and will resort to open defecation (Dankelman et al. 2009; Wendland et al. 2012). Therefore, men and women must have equitable and representative say in sanitation projects to ensure their individual needs are met (UN-Water 2006; World Bank 2010; Tilley et al. 2013).

There are increasing guidance documents on incorporating gender in water and sanitation (AusAID 2005; ADB 2006; UN-Water 2006; AfDB 2009; World Bank 2010; UNRWA 2011; IASC 2017; Tsetse and Alleman 2017). A notable early contribution is the World Bank's toolkit for gender in water and sanitation in 1996, which contains numerous methodologies appropriate for the national, district, or village levels (Fong et al. 1996). Methodologies for gender inclusion at a national level include policy inventories, household sample surveys, and household record-keeping, whereas the district or village levels should focus on community calendars, seasonal water supply and sanitation profiles, walking tours, spatial maps, focus-group interviews, group and community interviews, and community portraits (Fong et al. 1996). It is often recommended that consultation should be done with both separate and mixed-gender groups, and having an enumerator who is the same sex as the group members can encourage conversation (Fong et al. 1996; World Bank 2010; Rop 2011; IASC 2017). Moreover, where possible, a gender and/or social-science specialist should be included for gender studies at the onset of these projects (Rop 2011; IASC 2017). The water and sanitation technology world is often male-dominated (UN-Water 2006; Tilley et al. 2013), and this means that gender considerations may not be incorporated.

Despite the growing portfolio of guidance documents on incorporating gender in water and sanitation programs, there is limited understanding of how to account and validate gender considerations in designing toilet systems. Gender in water and sanitation is centered on the societal interactions and roles of males and females (Fong et al. 1996; Dankelman et al. 2009; Tilley et al. 2013; IASC 2017).

¹Executive Director, Biomass Controls, 105 Hood St., P.O. Box 3650, Durham, NC 27701. ORCID: <https://orcid.org/0000-0002-7011-6768>. Email: myles@biomasscontrols.com

²Lecturer, Cranfield Water Science Institute, Cranfield Univ., Cranfield MK43 0AL, UK (corresponding author). ORCID: <https://orcid.org/0000-0001-7370-6758>. Email: a.parker@cranfield.ac.uk

³Research Fellow, Cranfield Water Science Institute, Cranfield Univ., Cranfield MK43 0AL, UK. Email: toolaram.anju@gmail.com

⁴Research Professor, Dept. of Electrical and Computer Engineering, Duke Univ., Durham, NC 27708. Email: stoner@duke.edu

Note. This manuscript was submitted on February 20, 2019; approved on December 12, 2019; published online on April 2, 2020. Discussion period open until September 2, 2020; separate discussions must be submitted for individual papers. This technical note is part of the *Journal of Management in Engineering*, © ASCE, ISSN 0742-597X.

A gender lens here is interpreted to mean a conscious and deliberate perspective that pays attention to gender differences and cultural norms as well as social relations seeking a diverse understanding of practices, preferences, and aspirations. This could mean differences arising from both biological sex and gender identity. Gender-lens studies can offer a path for using a practical and structured methodology to analyze societal interaction with sanitation systems (Fong et al. 1996; Tilley et al. 2013) built on approaches such as formative research, and this can parallel technology innovations for better social and cultural inclusion in research and development (R&D).

This lens approach to observing or thinking can help to establish a more complete and less biased standpoint from which to understand design or a project implementation. Understanding through a gender lens has the potential to lead to better interventions and products by revealing opportunities to respond to unique preferences and practices and help to mitigate risks in operation or adoption. Thus, this paper aims to highlight the approaches, consequences, and lessons learned when venturing to apply a gender lens to technology innovation in sanitation. Additionally, the paper also explores the influence of the composition of the R&D teams on gender considerations in their project. This study is unique on looking at the methods and mechanics of incorporating gender in the R&D of sanitation technology innovation.

Methodology

The cohort selected for this study was the grantees supported by the Bill and Melinda Gates Foundation (BMGF) through the Reinvent the Toilet Challenge (RTTC). RTTC aims to revolutionize the sanitation industry and create novel and aspirational treatment technologies that are capable of onsite pathogen treatment and waste reduction, thus eliminating the need for handling and transport and creating value for the human waste resources. Approaches are off the grid, meaning not connected to sewer, electrical, or water systems. This cohort is ideal for this study because they are all actively doing R&D at present and are diverse in nationality, discipline, and approach. On a practical level, it was easy to contact and identify them with the help of the Bill and Melinda Gates Foundation.

The study included (1) an online survey sent to the full set of grantees identified by BMGF as part of the transformative technology grant portfolio, and (2) telephone interviews conducted with a self-selecting subset of the grantees that completed the online survey. The survey inquired about how the grantees considered the needs of men and women in the R&D processes and prototype testing of their RTTC technology products. It sought their input regarding gender considerations for both the design of the user interface and the processing technology or tool development. The survey also gathered information regarding the gender composition of the grantees' overall team and their leadership teams.

The survey was designed by the authors. The online survey and interview questions were also reviewed and approved by research ethics bodies in the US and the UK in December 2017. An email requesting participation in the online survey was sent to 41 Reinvent the Toilet grantees identified by BMGF as grantees in the portfolio. Request for participation was sent out by the authors in January 2018. Responses were collected without personal identifiers using the online questionnaire platform Qualtrics. Responses to the 17 question survey were collected in January and February 2018, with 27 teams agreeing to participate in the survey and 17 respondents going on to thoroughly complete the questions in the online survey form. Results of the online survey were tabulated

using the Qualtrics software, and quantitative analysis was performed using Microsoft Excel 2013.

Follow-up interviews were conducted with 14 teams that expressed a willingness to participate in the more in-depth discussion and provided contact points. These grantees were from the United States, the UK, Austria, India, and South Africa. The authors conducted interviews during March–April 2018, with the discussion averaging 40 min in duration. A list of questions is provided as Supplemental Data. Qualitative analysis of the interview notes and transcripts was completed using NVivo version 11 software for thematic analysis to include interview word mapping and diagramming interview themes and associations.

Results

The R&D teams were all developing some form of technology to enable the decentralized treatment of human excrement, focusing on the treatment of urine, feces, or both. With a few exceptions, most participants represented teams that were also developing user interface and/or toilet cabins to be adjacent to their waste-processing technologies (Fig. 1).

Generally, the teams reported being broadly aware of the importance of gender-informed thinking in the context of the sanitation challenges they are working to address. A majority of the teams (63%) reported referring to published literature about user practices and preferences to inform the design of the RTTC system, and nearly 90% of those respondents noted that the literature review called attention to the needs and preferences of women and men.

The interviews asked participants to indicate when in their process of R&D and how they considered the different biological and cultural needs of women and men. Interviews revealed that R&D teams believed that women are particularly concerned about space, lighting, privacy, menstrual hygiene management, disposal facilities, and children [Fig. 2(a)]. Design issues associated with men included their usage patterns such as frequency; sitting versus standing; and urinals, bowl, and pedestal design, among others [Fig. 2(b)]. These findings confirm that teams were aware of gender considerations.

Waste-Processing Technology

In the follow-up phone interviews, 29% of the participants indicated that they believed that the processing of waste may not have required a gender lens, noting that gender had no impact on this part of technology. However, gender considerations would exist around

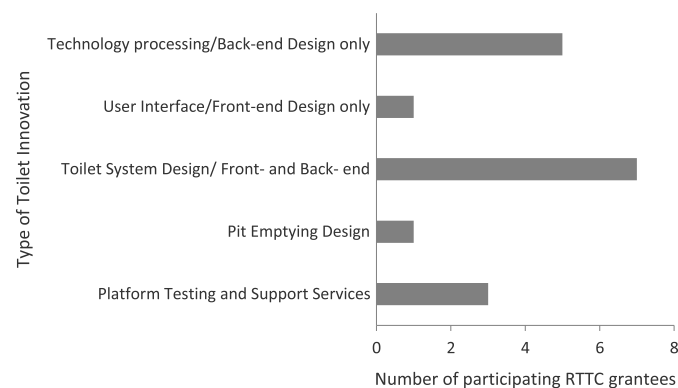


Fig. 1. Distribution of toilet innovation concentration among the participating RTTC grantees ($n = 16$).



Fig. 2. Word cloud associated with (a) females; and (b) male issues.

the requirement for treating and/or disposing sanitary napkins and neutrality in the design of the waste processing to accommodate any user interface (Table 1).

Nevertheless four teams took a more comprehensive approach to their design processes. One team thought about what waste may be generated and included methods to account for menstrual blood and menstrual absorbents as part of the waste to be processed in their decentralized technology. Only 2 of 14 teams thought about the how common muscular strength of men and women is often different. This is relevant because in some of the technologies, users may be required to take some action to facilitate or activate the waste processing; thus, understanding the gender of the user may impact the tension or force required for processing activation.

The teams are developing innovative ways to separate and treat waste onsite. Through the novel waste-processing innovations, some technology approaches treat the liquid waste for various reuse applications or may treat the feces to generate energy or a create a pathogen-free soil supplement. Four of the R&D teams report surveying men and women for their feedback about these processing steps. For one team, this included gathering perceptions on water reuse for flush or body washing and odor from onsite treatment or onsite combustion of feces. They found that women were more sensitive to malodor than men.

Teams that were most advanced in their thinking about gender did reveal important nuanced findings about users' perceptions of their technology. One team completed male-only, female-only, and mixed-gender focus-group discussions. In one example of a shared

Table 1. Areas recognized by participating RTTC grantees to have a gender influence

Attributes	Criteria
Engineering treatment process	
Menstrual hygiene management	<ul style="list-style-type: none"> • Designing a treatment system for sanitary napkins • Threats presented by sanitary napkins to the treatment processes
Cleanliness and odor	<ul style="list-style-type: none"> • Both genders, especially women, will not use toilets that are unclean or emit odor • Threats presented by cleaning solution to the treatment processes
Pure waste stream	<ul style="list-style-type: none"> • Threats presented by contamination of faeces and/or anal cleansing materials in systems that require pure urine streams • Difficulties to find user interfaces to capture pure urine streams; men are easier than women
Size and scale of technology process	<ul style="list-style-type: none"> • Aspirations for household size design because women could benefit from privacy and security
Operation of technology	<ul style="list-style-type: none"> • Technology designed for men strength and physiology because men would be operating the machine
User interface and cabin design	
Location	<ul style="list-style-type: none"> • Location of the toilet cabins on streets; • Presence of privacy screen in front of toilets • Locations of urinals within or outside of toilets • Type and location of ventilation system • Presence and type of lighting, e.g., bulbs or natural lighting • Type of ecosan/UDDT plates used to get separate waste streams • Aesthetics of toilets • Ease of use, e.g., instructions easy to understand, flush mechanism easy to use • Robustness of building materials • Exposure of users to human waste or part of the toilets, e.g., touching pan surfaces • Difference in control and direction of urine streams during urination
Design requirements	<ul style="list-style-type: none"> • Inclusion of other facilities into the toilet cabins, e.g., wash basins, pad dispensing machine, sanitary disposal bins, or shoots • Inclusion of pay areas for kids • Cleanliness and odorless • Behaviors, e.g., sitting versus squatting, sitting versus standing • Feeling of privacy, security, and comfort when using the toilet and wanting to use the toilet
Service inclusions in cabin	
Behavior, attitude, and practices	

Note: UDDT = urine diversion dry toilet.

toilet facility in India, both men and women were surveyed about their perception of collecting menstrual absorbents and using thermal treatment to process MHM waste. Both groups were highly supportive of this onsite collection, and the majority were supportive of the proposed thermal treatment method. This input provided valuable feedback to the technology team and furthered the direction of their prototype development.

In another example, odor was explored by five teams. Odor and cleanliness are naturally questions of concern with toilet facilities. However, the question is unique in these novel technologies given how these technologies process waste onsite. Unlike piped sewerage systems, these processing units place a user in close proximity to the treatment process. One team explored gender and odor perceptions. Women were found to be more sensitive than men to the processing odors. This input was useful feedback to innovators and pushed them to work harder to further process improvements such as insulation and additional polishing steps for recycled water. If this team had surveyed only men and not women in this example, there may have been less push for process improvements in early prototype iterations.

In interviews with RTTC grantees, open-ended questions were asked about how systems meet the unique needs of women and girls, and separately, the needs of men and boys. When focused on the waste-treatment elements of their R&D and prototyping, five teams had substantive observations. The best technical examples came from the teams that designed for menstrual waste management as part of their processing systems. Additional examples reflect bigger-picture thinking in noting communitywide benefits and how onsite processing will safeguard health and the environment, and that this potential benefit has a large impact, especially for women given their typical family caretaker and food preparation roles in the community.

User Interface and Toilet Cabin Design

Five of the research teams, although focused on innovative waste-treatment technologies, also took on the challenge to identify better user interfaces or toilet cabin designs. New user-interface designs were researched in order to achieve source separation to facilitate waste processing or to deliver resource-saving or resource-recovery features. Three teams took on the design of toilet cabins that might be adjacent to their treatment system given the importance of the cabin to meet preferences and aspirations to help support use of these facilities (Table 1).

In one example, a R&D team worked to design natural lighting and ventilation elements into the toilet cabin design. Women user

feedback guided the team to adjust plans away from louvred windows to the use of ventilation fan in the louvred window. Women felt men might be able to peek-in or put a small camera device in the louvred window, whereas the fan would help block viewing while still achieving the lighting and ventilation goals. These insights may not have been realized if only male inputs had driven cabin designs.

The location of the toilet stalls within a block or location of stand-alone toilet cabins was also explored. Female user input directed the placement of toilets in a way that shielded the entrance from the male side or in a setting where women felt safe entering and exiting the toilet. Privacy and safety emerge as priorities for women from these user insights.

In another example, a team worked to develop toilet facility lighting for a girls' school by deploying technology that is able to generate energy from incoming urine. The team was motivated by the demand for better lighting for safety and security for girls at school at their toilet block; however, they faced many design challenges in adapting the user interface proven effective with men and boys to meet the biological requirements for girls. The application of a gender lens revealed the aspiration for lighting and but also challenged the team to adapt the user interface.

In the online survey, 50% ($n = 8$) of the teams reported that they did take account of gender differences in designing their user interface, whereas 44% ($n = 7$) did not evaluate how women and men experience the user interface. After prototypes were developed, a majority of the teams (69%, $n = 11$) did report completing surveys with prospective users to evaluate gender differences in the course of prototype testing.

Five teams used or developed urine-diversion toilets or unique toilet bowl designs to optimize waste segregation or waste processing after a person uses the toilet. Biological differences were frequently recorded to understand the unique needs of the users and facilitate optimal technology performance and use. However, the results show 41% of the teams that developed user-interface designs did so without evaluating gender differences. Three teams reported that they thought of gender to mean women and girls. Many teams did not initially have the foresight to solicit feedback from men and boys. Among the few teams that completed extensive user survey work, feedback from women and men revealed discomfort with shallow bowls and splashback effects when using the new designs. One team found through survey work that users were concerned about the bowl staining with menstrual blood, which did not provide adequate privacy. In other examples, shallow toilet bowls designed to optimize flushing with

Table 2. List of instruments and techniques used to incorporate gender in toilet innovation

Type	Measures
Instruments	<p>Group interviews: focus groups; community meeting/stakeholder meetings; participatory workshops</p> <p>Individual interviews: in-depth user interviews; key respondents</p> <p>Surveys: user surveys; feedback surveys; household surveys</p> <p>Key specialists, e.g., design anthropologist, social-science specialists</p> <p>Literature: research publications, books, gray literature on toilet design; engineering processes; field trials; user interface and user acceptance; gender-specific topics, e.g., MHM, survey designs</p> <p>Conferences, seminars, and workshops: attending gender-specific workshops for training, sensitization, and networking</p> <p>Technology: using thermal imaging, e.g., for investigating urine streams</p> <p>Field testing: in groups or separate sexes</p>
Techniques	<p>Surveys and interviews carried out in groups of separate sexes and mixed-group settings</p> <p>Field workers and interviewers include sex of those targeted, e.g., female interviewer for all-girl school and from local community/area with knowledge of environment and language</p> <p>Continuous feedback surveys</p>

low volumes of water created a negative experience for men due to proximity of their male genitalia touching to the bowl or experiencing splashback.

Approaches and Techniques for Studying Gender

Half of the teams (50%, $n = 8$) used multiple methods to collect gender-differentiated input. Methods included individual surveys, household surveys, focus-group discussions, and community meetings (Table 2).

The most field-ready technology development teams did show a greater recognition for gendered field input. Three teams reported challenges in engaging with households and communities, noting it often takes extra effort to gain female participation. Due to time or culture, access to women in households or gaining women's full participation in community meetings is more difficult than collecting input from men. Communities often nominate a spokesperson, and it can be more challenging to get communities to nominate women for this role. This weighed on the minds of several of the R&D teams, but they did not know how to address it. Of the grantees, 70% were also not sure of how to fully incorporate gender in their toilet innovation scheme, and thus, as a result of this research, have called for assistance in identifying tools and specialists to assist them.

Team Composition

The survey asked respondents to share facts about the female and male composition of their research and project management teams. The results showed that all the teams have a majority of men (55%) on the team, with women (45%) also being represented. One-quarter of the teams have more women than men in leadership roles, and three teams have female Project Directors. This finding of more men and women (Fig. 3) is not surprising given the engineering fields are generally found to have more men than women in their ranks. Having mixed-gender teams can influence organizational behavior (Quelhas et al. 2019) and knowledge sharing (Ni et al. 2018). It also seems likely that teams with women in decision-making roles would be more likely to consider the needs of women.

The respondents noted that they are aware of gender imbalance of their teams and strive for equal participation, but that recruitment and hiring is always done based on merit and is not based on any gender quota system. Among the surveyed teams, the leadership of most teams are headed by men, but many teams have women on their leadership teams, and 25% of the participating teams are led or directed by women.

Discussion

The R&D teams participating in the research show an interest in applying a gender lens in their work to design better sanitation systems. The interest and goodwill to do so, however, often did not translate into early and consistent design thinking and prototype testing to incorporate the needs and preferences of both men and women into their work. Some of the teams did not apply a gender lens, and many did so late in the design process, learning valuable lessons for the importance of gender integration.

There is a gap in gender integration reflected in the results. In some cases, the perspectives of men were left out, and at other times, the perspectives of women were not well accounted for in the R&D and testing activities. For many teams, when asked to think about the different uses and types of people involved in the process, the assumption was that gender means the concerns of women. Therefore, the needs of men and boys were not addressed, or it was later found through surveys that men had negative experiences with the prototypes. If men are not using improved sanitation, the whole community has negative health consequences (Carter 2017). No teams focused on meeting the needs of transgender people; this is an emerging area of research that needs increasing attention (Boyce et al. 2018). Indeed, most of the findings are teams who respond to differences in biological sex rather than gender identity.

A big gap for many teams was the lack of attention to menstrual hygiene management practices and how these practices drive facility use and generate additional waste streams to be accounted for in onsite waste processing. In contrast, some teams focused exclusively on menstrual hygiene management without considering anything else through a gender lens. Across the sanitation sector, the focus on menstrual hygiene management tends to focus on disposable absorbent access and washing facilities for reusable absorbents, with far less attention paid to menstrual absorbent waste management (Elledge et al. 2018). Broader issues around gender-sensitive practices and preferences for women and girls, such as female urination, safety, privacy, lighting, and space, were often addressed, but not consistently across teams.

Decentralized waste-processing technology development was a key focus for the teams. Survey participants generally had at the core of their grant funding a mandate to complete R&D on fecal sludge processing or develop a fecal-sludge-management tool design. Many respondents considered their waste-processing technology to have no impact on gender and de-emphasized the value of design thinking or survey feedback from women and men about perceptions of their technology prototype systems. The gender-lens

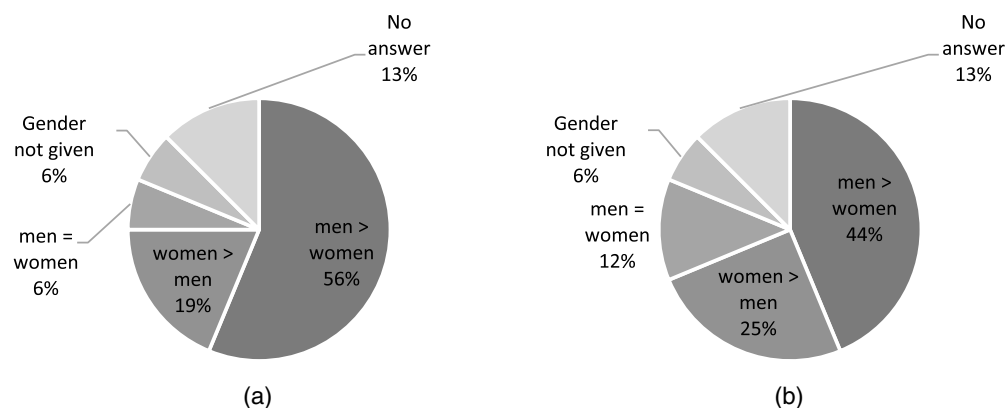


Fig. 3. Gender proportions related to (a) general team composition; and (b) leadership composition.

survey revealed that many of the teams assumed gender differences did not apply. Because the focus was on waste-treatment technologies and not facilities that the user would always interact with, the assumption often made that gender had no impact on processing. This assumption does not allow for different gender perceptions of water reuse, odor, or treatment approaches (e.g., combustion of feces) to be revealed. Also, some mechanical devices that are being developed may require human muscular strength to apply force or tension to activate or operate the device. Here too, gender differences are important to record because they may influence design.

This exploratory research was focused exclusively on RTTC grantees, which by definition excludes other sanitation innovators. This may exclude small-scale, grassroots innovators without the capacity to apply for funding from a large international funding body, or those who disagree with the RTTC's technology-focused approach. BMGF do encourage grantees to think about gender, but it is not mandated, so in this particular respect there should be little bias. The male and female composition of R&D and project management teams was slanted toward the teams being made up of a majority of men. Women were present, and many teams had female leadership representation. Conversations around team composition, however, suggested team composition was not a predictor of gender-lens design thinking. Expertise in international development field work and years of experience with user-design approaches among the teams were larger factors associated with the team's skills in executing gender-differentiated thinking.

Although all grantees had the opportunity to respond to the online survey and hence participate in a follow-on interview, only a subset participated. There may be a bias toward those participating because those were the ones wrestling with gender considerations or more attuned to thinking about them. This bias is further compounded by the fact that each grantee could have nominated a team member to complete the survey and follow-up interview, and some teams may have nominated a gender advocate whose approaches may not be fully embedded within their own team. Thus, the picture across all grantees could probably be that even less attention is being paid to gender than is reflected in these results.

The authors have acknowledged that this research was commissioned by the Bill and Melinda Gates Foundation in order to survey their RTTC transformative technology grantees. With that said, BMGF staff have given the researchers free rein and did not seek to influence the survey design or the presentation of results. Two of the authors were also interview respondents, representing their own R&D teams, and the remaining two have been involved in the R&D teams as well. Although this gave them an ability to understand very clearly the challenges that the teams are facing, it is also possible that it influenced or biased the coding and presentation of the results here.

Conclusions

The findings suggest more can be done to encourage and promote gender-informed thinking in research and development in the water and sanitation sector. Purposeful grant-making by funding agencies that outlines gender expectations is one administrative measure that could give structure and set clear expectations for R&D teams. Specific definition of goals, monitoring, and evaluation elements, as well as requirements for results frameworks or impact measures, explicitly report with gender-disaggregated data are steps that will enhance application of a gender lens.

One of the major implications of the findings with the RTTC R&D teams is that knowledge and confidence in how to execute gender-differentiated design thinking is missing. More experience

is needed to bring in the gender perspective, and capacity-building in this area could be advantageous to greater integration. There is a gap in knowing how, when, and where in the process to look through a gender lens. R&D teams need tools to guide them in asking the right questions and in measuring and reporting gender considerations.

The gap in knowledge and experience highlights the importance of developing champions, role models, and resource tools for guidance on how to bring a gender lens in technology development cycles. Definition of concepts, expectations for gender integration, and identification of sanitation system gender factors will go a long way to helping teams perform better gender awareness and integration. There is a need in the sanitation sector for greater communication, references, and exchanges for guiding the consideration of gender in technology innovation. Another strategy for funding agencies might be to work extensively with a small set of teams, and coach and mentor them in their R&D and testing processes to drive toward gender-transformative product development.

There is also perhaps a bias that emerges among technical engineering design teams. Gender in sanitation and in international development is often the domain of social-science researchers. Many of the teams' responses suggest that they feel gender has no impact on technology, and therefore, not a priority for engineers involved in hardware R&D. These blinders to how the science of gender differences may play out in sanitation technology development are significant barriers to gender-informed technology and pose risks to technology adoption as prototype moves toward real products.

The findings about the male and female ratio of the R&D teams are not surprising. The engineering fields are historically male-dominated. The findings do call attention to the importance of broader initiatives to advance women in science, technology, engineering, and math (STEM), in research institution leadership, and in initiatives to place women in project leadership roles.

Data Availability Statement

Some or all data, models, or code generated or used during the study are proprietary or confidential in nature and may only be provided with restrictions. Interview transcripts may not be provided because this would compromise the anonymity of participants.

Acknowledgments

This publication is based on research funded by the Bill and Melinda Gates Foundation. The findings and conclusions contained within are those of the authors and do not necessarily reflect positions or policies of the Bill and Melinda Gates Foundation.

Supplemental Data

Questions for telephone interviews are available online in the ASCE Library (www.ascelibrary.org).

References

- AfDB (African Development Bank). 2009. *Checklist for gender mainstreaming in the water and sanitation sector*. Abidjan, Core d'Ivoire: AfDB.
- Asian Development Bank. 2006. *Gender checklist: Water supply and sanitation*. Manila, Philippines: Asian Development Bank.

- AusAid. 2005. *Gender guidelines: Water supply and sanitation: Supplement to the guide to gender and development*. Canberra, Australia: Australian Agency for International Development.
- Belur, J., P. Parikh, N. Daruwalla, R. Joshi, and R. Fernandes. 2017. "Perceptions of gender-based violence around public toilets in Mumbai slums." *Int. J. Comp. Appl. Criminal Justice* 41 (1–2): 63–78. <https://doi.org/10.1080/01924036.2016.1240094>.
- Boyce, P., et al. 2018. "Transgender-inclusive sanitation: Insights from South Asia." *Waterlines* 37 (2): 102–117. <https://doi.org/10.3362/1756-3488.18-00004>.
- Carter, R. C. 2017. "Can and should sanitation and hygiene programmes be expected to achieve health impacts?" *Waterlines* 36 (1): 92–103. <https://doi.org/10.3362/1756-3488.2017.005>.
- Caruso, B. A., T. Clasen, K. M. Yount, H. L. F. Cooper, C. Hadley, and R. Haardörfer. 2017. "Assessing women's negative sanitation experiences and concerns: The development of a novel sanitation insecurity measure." *Int. J. Environ. Res. Public Health* 14 (7): 1–22. <https://doi.org/10.3390/ijerph14070755>.
- Dankelman, I., J. Muylwijk, C. Wendland, and M. Samwel. 2009. *Making sustainable sanitation work for women and men-integrating a gender perspective into sanitation initiatives*. Utrecht, Netherlands: Women Engage for a Common Future.
- Elledge, M., A. Muralidharan, A. Parker, K. Ravndal, M. Siddiqui, A. Toolaram, and K. Woodward. 2018. "Menstrual hygiene management and waste disposal—A systematic review." *Int. J. Environ. Res. Public Health* 15 (11): 2562. <https://doi.org/10.3390/ijerph15112562>.
- Fong, M. S., W. Wakeman, and A. Bhushan. 1996. *Toolkit on gender in water- and sanitation gender toolkit*. Series No. 2. Washington, DC: World Bank.
- IASC (Inter-Agency Standing Committee). 2017. *The gender handbook for humanitarian action*. Geneva: IASC.
- Kwiringira, J., P. Atekyereza, C. Niwagaba, and I. Günther. 2014. "Gender variations in access, choice to use and cleaning of shared latrines; experiences from Kampala slums, Uganda." *BMC Public Health* 14 (1): 1–11. <https://doi.org/10.1186/1471-2458-14-1180>.
- Ni, G., Q. Cui, L. Sang, W. Wang, and D. Xia. 2018. "Knowledge-sharing culture, project team interaction and knowledge-sharing performance among project members." *J. Manage. Eng.* 34 (2): 04017065. [https://doi.org/10.1061/\(ASCE\)ME.1943-5479.0000590](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000590).
- Quelhas, A. D., J. R. F. Filho, J. V. Neto, and V. Pereira. 2019. "Model to measure adherence of culture, climate and organizational behavior in a construction company." *J. Manage. Eng.* 35 (4): 05019003. [https://doi.org/10.1061/\(ASCE\)ME.1943-5479.0000688](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000688).
- Rop, R. 2011. *Mainstreaming gender in water and sanitation: Gender in water and sanitation*. Nairobi, Kenya: Water and Sanitation Program, World Bank.
- Tilley, E., S. Bieri, and P. Kohler. 2013. "Sanitation in developing countries: A review through a gender lens." *J. Water Sanitation Hyg. Dev.* 3 (3): 298–314. <https://doi.org/10.2166/washdev.2013.090>.
- Tsetse, D., and P. Alleman. 2017. *Gender-responsive water, sanitation and hygiene: Key elements for effective WASH programming, (March)*. New York: United Nations Children's Fund.
- UNRWA (United Nations Relief and Works Agency for Palestine Refugees in the Near East). 2011. *Gender analysis manual*. Amman, Jordan: UNRWA.
- UN-Water. 2006. *Gender, water and sanitation: A policy brief*. Geneva: UN-Water.
- Van de Lande, L. 2015. *Eliminating discrimination and inequalities in access to water and sanitation*. Policy Brief 29. Geneva: UN-Water.
- Wendland, C., I. Dankelman, C. Ruben, I. Kunze, M. Sommer, and D. Mbalo. 2012. *Integrating a gender perspective in sustainable sanitation*. Factsheet of Working Group 7B. Eschborn, Germany: Sustainable Sanitation Alliance.
- WHO (World Health Organization). 2017. *Progress on drinking water, sanitation and hygiene, 2017 update and SDG benchmarks*. Geneva: WHO.
- World Bank. 2010. *Mainstreaming gender in water and sanitation*. Water and Sanitation Program Working Paper. Washington, DC: World Bank.



DSPACE

<https://dspace.org/>

A gender lens into sanitation technology innovation

Elledge, Myles; Parker, Alison; Toolaram, Anju; Stoner, Brian

2020-04-02

American Society of Civil Engineers (ASCE)

[https://doi.org/10.1061/\(ASCE\)ME.1943-5479.0000775](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000775)

Elledge M, Parker A, Toolaram A, Stoner B. (2020) A gender lens into sanitation technology innovation. Journal of Management in Engineering, Volume 36, Issue 4, July 2020, Article number 06020002