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Weight of Water: Who Carries the Burden of Water Interventions?

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Weight of Water: Who Carries the Burden of Water Interventions?

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An abstract of
A thesis submitted to the
Faculty of the
Rollins School of Public Health
of Emory University
in partial fulfillment of the
requirements for the degree of
Master of Public Health in
Global Health
2020

Abstract

Weight of water: who carries the burden of water interventions?
By Janice Shainy D'souza

Background and Objective: Unsafe drinking water is associated with 9.1% of the global burden of all diseases and 6.3% of all deaths are due to unsafe water, inadequate sanitation, and poor hygiene. To address this burden of disease, water quality interventions implemented at the household level and designed to provide safe drinking water have been shown to reduce diarrhea frequency by 31%. Notably, these household point of use water interventions (chlorination, filtration etc.) typically rely on individuals to perform tasks associated with the intervention, such as water collection, treatment, and storage. As women are responsible for the majority of activities associated with carrying and managing water for households, there is a need to understand how water quality interventions engage and impact these individuals (women, girls, boys, and men) to achieve intervention goals.

Methods: Water quality interventions aimed at reducing diarrheal disease were compiled as part of a systematic review by Clasen *et al, (2015)*. Interventions that required a person to perform an intervention-related activity were eligible for inclusion for further review. We then determined who was identified to perform the intervention activity, and reviewed and evaluated interventions activities using the WHO Gender Responsiveness Assessment Scale (GRAS). The GRAS provides a framework, comprised of five designations: gender-unequal, gender-blind, gender-sensitive, gender-specific, and gender-transformative. Data from each included study, including intervention type, geography, household number of households engaged, etc., were extracted, compiled into an Excel database, and summarized (Microsoft, 2016).

Results: Forty-six out of 52 articles met our eligibility criteria and were included in our analysis. Overall, 100% of the interventions were classified as gender unequal (63%) or gender blind (37%) and none of the interventions were classified as gender-sensitive, or gender transformative. Among the 46 selected studies, the interventions targeted different members of the household to perform the required intervention actions or behaviors. Mothers were targeted by 44% of the interventions and caregivers by 37% of the interventions. Women (non-caregiver and non-mother) were targeted by 26% of the interventions. Overall, women were targeted by 91% of the interventions. Two percent of the interventions targeted the eldest daughter of the household specifically. Seven percent of the interventions targeted male members of the household.

Conclusion: Women and girls are disproportionately targeted when it comes to point-of-use water interventions and bear the burden of ensuring access to safe water, including those associated with water interventions. This study demonstrates public health practitioners and developmental agencies must critically examine gender roles, norms, and dynamics as part of formative research to inform intervention design. To build healthier, equal, and inclusive societies, there is a need to question gender roles, from the researchers all the way down to the manner in which programs are designed, in order to advance gender equality.

Acknowledgements:

This thesis would not have been possible without Dr. Bethany Caruso, who taught me about gender considerations even before we started this project. Her work in the WASH sector is essential and an inspiration to me. I am deeply thankful for her time, guidance, and encouragement during this process. Her detailed feedback showed me her investment in my success and what a good advisor looks like. My gratitude also to Julia Silva Sobolik, who spent numerous hours guiding me throughout this thesis with kind words and encouragement. I was in awe of her thoughtfulness and intelligence when she was my TA, and this process has only heightened that awe. Her guidance gave me the confidence to undertake this project because I knew she would be there to catch me if I fell. Learning from and with these two excellent advisors in the course of my thesis has been a true gift.

I have been fortunate to gain knowledge and skills from a number of mentors during my time at the Rollins School of Public Health. My deep thank you to Dr. Roger Rochat, who is the reason I came to Emory University, and to Lydia Karch for introducing me to him and always reading my drafts. And to the lifelong friends I have made at Rollins, who I have learned with and from. A special thank you to Haley Biddle, who read every single draft of this thesis.

None of this would be possible without the investment Berea College made in me and for Max Paschall, who believed in me and helped me apply. Every one of my achievements is a testament to that school and its free tuition mission, which invested in me as a first-generation Indian student, to come to the U.S. and taught me to write, critically think, and contra dance. I will forever be grateful to the late Dr. Michelle Tooley who picked my application from thousands and instilled in me an appreciation of a hard work ethic.

My life is a testament to families and individuals that welcomed me into their lives and been generous with their time and resources – Ambika Roos and Maxwell Kaufman for reminding me to take breaks and being a sounding board during the last two years and before, Barb and Aleeza Ribner for consistent study snacks and company, Jessica Webster for driving me to school and helping me start my thesis work, Kate Black, who reminded me there was no shame in taking extra time to finish my thesis and for telling me to "get a grip," my neighborhood in Decatur for always sharing resources including a monitor for my home office during the coronavirus pandemic. My partner and friend, Jordan Engel who helped me flourish in a foreign land, kept our home clean, nourished me, and packed endless lunch boxes for me and my friends as I went to school.

Ann Butwell for being my bonus mother. My mother, Margaret, for the innumerous sacrifices she made for me to be here, and my sister, Jovita, who prayed the rosary for me and with me every time I felt I was not capable of finishing a chapter. To the women in my family, and around the world, for all the unpaid work they do for the health of their families. This thesis is for my niece Jinelle, who ensured that the chores were equally distributed between her and her brother.

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Chapter 1: Introduction

Unsafe drinking water represents a serious threat to the health and wellbeing to people globally. Unsafe drinking water is associated with 9.1% of the global burden of all diseases and 6.3% of all deaths are due to unsafe water, inadequate sanitation, and poor hygiene (World Health Organization, 2019a). Unsafe drinking water has particularly deleterious effects on children under the ages of 5 in low and middle-income countries. Among children <5 years, approximately 11% of deaths worldwide are attributed to diarrheal disease with an estimated 88% of these cases caused by unsafe water or improper sanitation (Pal, Ayele, Hadush, Panigrahi, & Jadhav, 2018). Diarrhea alone is more fatal to children than the combined mortalities from malaria and tuberculosis worldwide (Rana, 2009).

The WHO estimates that almost 10% of the total burden of diseases worldwide could be prevented by access to safe drinking water and water resource management strategies (World Health Organization, 2019b). However, availability and access to safe drinking water is an increasing concern for global communities. Adequate access to safe water, improving the quality of water sources, treating household water, and storing water safely are all important steps to ensuring safe drinking water and to decreasing diarrheal diseases. Public health practitioners have focused on interventions that improve water quality at the point of use (POU) through household water treatment and safe storage. The four most common household water treatment options are chlorination, filtration (biosand and ceramic), solar disinfection, and flocculation (Clasen et al., 2015). These point of use interventions have documented reductions of diarrheal disease in end users. A review by the WHO showed that there is a 31% reduction for all people in diarrhea frequency through water quality interventions (World Health Organization, 2019b). Notably, point

of use water interventions typically rely on individuals to perform tasks associated with the intervention, such as water collection, treatment, and storage.

Among households without direct access to a water source, such as a household piped water connection, women are responsible for the majority of carrying and managing of water for households(Graham, Hirai, & Kim, 2016). Women and girls spend a greater proportion of their time travelling to water sources and collecting and treating water than boys and men (Lowe, Ludi, Le Sève, & Tsui, 2019). Socially prescribed roles can result in women burdened with multiple responsibilities (parenting, household labor) while men in the household typically do not contribute an equal share in housework work (A. Coles & Wallace, 2020). Currently, no studies to date have evaluated how water quality interventions engage women and girls, despite their roles as the domestic water collectors and household stewards.

The World Health Organization has developed a Gender-responsive assessment scale (GRAS) for evaluating gender in development programs and policies with the goal of integrating the use of gender into these programs (Men, Frieson, Socheat, Nirmita, & Mony, 2013). GRAS provides a framework, comprised of five designations: gender-unequal, gender-blind, gender-sensitive, gender-specific, and gender-transformative, for understanding approaches to integrate gender and highlights the differences between ignoring and addressing gender considerations. The GRAS tool has successfully been implemented to assess gender responsiveness of forestry policies in India (Tyagi, Das, & Economics, 2018), livestock ownership policies in Uganda (Njuki, Miller, & Markets, 2013), and measuring gender responsive approaches in measuring aid effectiveness (Pérez Piñán & Society, 2015). However, this GRAS scale has not yet been applied to evaluate gender responsiveness of water interventions and policies in global communities.

While POU water interventions have made positive strides in improving access and utilization of safe drinking water in global communities, understanding how these interventions engage women remains unknown. In order to advance health, safety, and gender equality in global communities, there is a need to evaluate how women and girls are engaged in these water interventions. The purpose of this study is to examine how water interventions aimed at reducing diarrheal illness engage women and girls as necessary actors for the implementation of the intervention. This study will investigate: 1) what proportion of water interventions engage women, girls, boys, and/or men, as necessary actors for the interventions' success/functioning; and 2) the ways women and girls are engaged according to the WHO Gender Assessment Scale.

Definition of Terms

Defined terms that are used throughout this manuscript include:

Safe water: Water is considered safe when it is free from pathogenic agents, free from harmful chemical substances, and ideally free from color and odor, and usable for domestic purposes (Park & Geriatrics, 2005).

Gender mainstreaming: assessing the different implications for people of different genders of any planned policy action, including legislation and programs, in all areas and levels (World Health Organization, 2011).

Gender unequal: perpetuates gender inequality by reinforcing unbalanced norm, roles and relations.

Gender blind: Ignores gender norms, roles, and relations.

Gender-sensitive: Considers gender norms, roles, and relations. However, does not address inequality generated by these unequal norms.

Gender-specific: Considers gender norms, roles and relations for women and men and how they affect access to and control resources.

Gender transformative: Considers gender norms, roles and relations for women and men and that these affect access to and control over resources.

Gender norms: Gender norms are social norms defining acceptable and appropriate actions for women and men in a given group or society. They are embedded in formal and informal institutions, nested in the mind, and produced and reproduced through social interaction. They play a role in shaping women and men's access to resources and freedoms, thus affecting their voice, power and sense of self (Cislaghi, Heise, & Illness, 2020).

Chapter 2: Literature Review

Globally, unsafe drinking water is a leading cause of child mortality due to diarrheal disease. Poor water conditions result in more than 800,000 deaths each year, mostly among children under age five (Gall, Mariñas, Lu, & Shisler, 2015). Particularly in countries with high rates of child mortality attributable to diarrheal disease, the responsibility of procuring safe drinking water predominantly falls to women and girls (Graham et al., 2016; Sorenson, Morssink, & Campos, 2011). Obtaining safe drinking water requires time and labor-intensive activities, such as traveling to and from water sources, and collecting and treating water. Importantly, because these tasks are conducted primarily by women and girls, they place an imbalanced burden on them involving physical labor, mental stress, and a substantial time commitment (Lowe et al., 2019).

Though gender inequality is a widespread experience globally, academic research concerning the role of gender in water and sanitation remains limited. Those who design and deliver water-related interventions and programs need to consider how they engage gender, especially as they develop effective processes and strategies for improving household water quality, access, and security. There is a need to understand how water-related interventions engage women and girls in order to address the concerns of imbalance in water burden across genders. The purpose of this study is to examine how water interventions aimed at reducing diarrheal illness engage women and girls as necessary actors for the implementation of interventions.

Access to Safe Drinking Water and Burden of Disease

Access to safe drinking water is essential for health, and economic and social development, and is recognized as a basic human right. Successive global targets relating to access to drinking water have been set since 1959, with aspirations for 100% global coverage by 2030 according to

SDG 6 (Ryu, 2019). In order to quantify access to safe drinking water, it has been imperative to first define the varying levels of drinking water access. The WHO/UNICEF Joint Monitoring Programme (JMP) (World Health Organization & Unicef, 2017) defines five drinking water access levels as follows:

1. Safely managed water is drinking water from an improved water source on premises. It is available when needed and free from fecal and chemical contamination.
2. Basic is drinking water from an improved source, provided the collection time including queuing, is not over 30 minutes for a roundtrip.
3. Limited is drinking water from an improved source for which collection time including queuing, is over 30 minutes for a roundtrip
4. Unimproved is drinking water from an unprotected dug well or spring.
5. Surface water is drinking water directly from a river, dam, lake, pond, stream, or irrigation canal.

Globally, 785 million people lack access to an improved water source, with 144 million people dependent on surface water (World Health Organization, 2019a). There is a difference in geographical distribution of lack of access of safe water. In 2017, nine out of ten of the 785 million people globally using limited services, unimproved sources or surface water lived in three regions: sub-Saharan Africa (400 million), Eastern and South-Eastern Asia (161 million), and Central and South Asia (145 million). More than half of the 144 million people who still collected water directly from rivers, lakes and ponds lived in sub-Saharan Africa (World Health Organization, 2019a). Furthermore, sources that are classified as “improved” are not always safe for

consumption, as numerous studies have found high levels of fecal indicators or pathogens in those same water sources (Bain et al., 2014).

At least 2 billion people around the world use a drinking water source contaminated with feces, leading to a public health crisis of diarrheal diseases, among the main contributors to global child mortality (Forde, Izurieta, & Ôrmeci, 2019). In terms of burden of disease, waterborne diseases consist mainly of infectious diarrhea, like cholera, shigellosis, and other protozoal and viral intestinal infections. Globally, 525,000 children under 5 years die due to diarrheal diseases every year (UNICEF, 2016b). Annually, 1.7 billion diarrhea episodes occurred among children under 5-years worldwide (Lancet, 2016).The burden of diarrhea, is not solely estimated by mortality. It is also a driver of malnutrition, cognitive development, altering immune responses, and other comorbidities (McCormick & Lang, 2016).

Beyond the burden of morbidity and mortality, water is intricately tied to politics, and economies. Governments or market actors are often responsible for the regulation and distribution of drinking water (Boelens, Getches, & Guevara-Gil, 2010). The macroeconomic implications of unsafe water may be dramatic: repeated diarrheal attacks can result in lost productivity and significant direct costs to the health sector (World Health Organization, 2008). Illness and lost wages can place additional strains on overstretched household budgets as well. An example of this was in 2014, when Ghana experienced a cholera outbreak. Households in the lowest income categories had the highest incidence of cholera (Awalime, Davies-Teye, Vanotoo, Owoo, & Nketiah-Amponsah, 2017). It is difficult to quantify the long-term economic impacts of the cognitive disorders and stunting associated with diarrheal illness and repeated infections.

The advantage of improving the supply of drinking water can translate into significant economic benefits for a developing country, with an estimated an 3.7 percent annual average

growth by developing countries with improved water and sanitation compared to 0.1 percent for those without these improvements (Sachs, 2001). Some of the economic benefits related to health impacts of improved water services are savings related to seeking less health care, savings related to productive time losses from disease, and savings related to reductions in premature mortality (Hutton & health, 2013). Health care costs to treat these health-related effects of unsafe drinking water are approximately $7 billion per year, which results in $63 billion per year in time lost (Hulton & World Health Organization, 2012).

Gender and Water

Gender and access to safe drinking water are inextricably related. *Transforming our world: the 2030 Agenda for Sustainable Development* and its 17 Sustainable Development Goals (SDGs) were adopted in 2015 by all member countries of the United Nations (Desa, 2016). The SDGs are seen as a universal agenda affecting all countries and require that all countries take actions to strengthen gender equality, stop climate change, and shift the world to sustainable development. While traditional development efforts have focused on one issue at a time, the SDGs are broader and have the potential to be more transformative. Gender equality is a cross cutting feature of *the 2030 Agenda for Sustainable Development* and is key to realizing women's and girls' rights and in catalyzing progress across all SDGs (Hepp, Somerville, & Borisch, 2019). *The 2030 Agenda* recognizes that development must balance economic, social, and environmental sustainability — especially those interventions which affect one another.

Policy documents such as the *2030 Agenda*, and the *Beijing Declaration and Platform for Action* (BPFA), with their powerful framework for gender equality policies and practices, offer a thorough examination and plan for addressing societal disparities. BFPA helped recognize the role of discriminatory laws and practices in driving gender inequalities such as violence and

early marriage (Women & Nations, 1996). It helped highlight the need for a universal agenda for change and integrated social norms throughout the 12 critical areas of concern, while envisioning gender equality in all avenues of life (Rees, 2002). In the early 1990s, "empowerment" was introduced to the wider development agenda by feminist scholars and activists through international conferences such as the UN-sponsored conferences in Cairo (1994) and Beijing (1995). Empowerment became a favored strategy for promoting gender equality (Sharma, 2008). At this same time, sustainability, participation, gender, and empowerment also became important concepts in the water sector. This shifted the focus from the technical requirements to the human dimensions of water supply. Dr. Sandy Cairncross (1992) published an influential paper reviewing the practical lessons learned in sanitation and water supply during the UN decade for Water and Sanitation (Cairncross & Mundial, 1992). The report emphasized the importance of "software" components defined as hygiene education, technical training, community participation, and women's involvement.

Across all fields of development, from education to reproductive health to human rights, there is a longstanding view that women and girls are the keys to any societal change (Langer et al., 2015). Women's participation in planning and managing water supply projects has been seen as a key element of the new mainstreaming approach. Women's participation has been promoted as a more efficient and economical approach to water supply projects by a variety of organizations (Desa, 2016). The shift from Women in Development (WID) to Gender and Development (GAD) in development approaches led to a similar shift in terminology in the water sector. Scholars showed that gender norms are significant in determining water access, collection, use, and management, as well as potential outcomes of water interventions (A. Coles & Wallace, 2020).

While the discourse in the water sector has shifted to include participation, demand responsive planning, local ownership, empowerment, and gender, the practice of water supply planning continues to be guided by an engineering and technical framework. The gender mainstreaming approach tends to mirror the engineering approach; rather than looking at the power relations and disparities between men and women, the gender approach is simplistic, standardized, and technical (Benería, Berik, & Floro, 2015). Gender disparities are viewed as a technical problem that can be solved with the right tools, and little attention is given to understanding gender and the underlying causes and determinants of inequalities in specific contexts (Wallace, Coles, & development, 2005).

Water and sanitation have strong gender dimensions that affect the use and management of the resource. The day-to-day experiences of how men and women experience water and sanitation differ across countries and cultures, and these differences and inequalities must be considered from the beginning of any public health intervention. A recent study showed that in two rural Brazilian communities there is still a clear labor division for water access among men and women (Silva, Sales, Lanza, Heller, & Rezende, 2020). In these communities, women are assigned functions related to the domestic environment, including activities concerning water, while men take on more specialized work. These assumptions and expectations on gender roles result in women and girls assuming responsibility for the water and sanitation activities and care of children, elderly, and the household in general (Li et al., 2001).

Around the world, women disproportionately bear the responsibility of domestic work, including cooking, cleaning, and managing the domestic water supply (Dankelman & Jansen, 2012). In the countries where half or fewer of the households have access to an improved water source, women are the most common water carriers (Graham et al., 2016; Sorenson et al., 2011).

Women and girls spend a larger proportion of their time traveling to water sources, collecting water, returning to the house, and treating water than boys and men (Lowe et al., 2019). Water is fetched by carrying 20-25 L containers on their head (Bimla, Gandhi, Dilbaghi, & Raina, 2003) or by loading multiple containers into a wheelbarrow (Geere, Cortobius, Geere, Hammer, & Hunter, 2018b).

Managing the household's water supply requires a significant time commitment on the part of women and girls'. The mean time needed to fetch water in sub-Saharan Africa is about 30 minutes per trip, and multiple trips may be necessary (Sorenson et al., 2011). According to UNICEF, women and girls spend 200 million hours every day collecting water and deem it as a "colossal waste" of their valuable time (UNICEF, 2016a). An analysis of water collection labor among women and children in 24 Sub-Saharan African countries found that an estimated 3.36 million children and 13.54 million adult females were responsible for water collection in households with collection times greater than 30 minutes. Further, female children were also more likely to be responsible for water collection than male children, across all countries. (Graham et al., 2016). Another study in Haryana, India found that women fetched and carried, on their heads, an average 23 vessels of water each day during the summer. This included 17 vessels in the morning and 6 in the evening (Bimla et al., 2003).

Population growth, weather fluctuations, and social upheaval have complicated the daily task of carrying water, especially for women who engage in this activity. Sorenson et al., studied the gender differences in 44 countries that participated in the MICS program, and found that women and children are the most common water carriers, and they spend over an hour per day supplying water to their households (Sorenson et al., 2011). Overall, it was noted that the amount of time women spend on household chores tends to be more when water infrastructure is

inadequate. The time-consuming nature of domestic duties when water is scarce negatively affects the performance of other social and economic activities.

However, time is just one measure of the cost of fetching water. There are also caloric expenditures involved, which can be especially detrimental during drought and other extreme conditions that can affect health and quality of life (J.-A. L. Geere et al., 2018b; Sorenson et al., 2011). Adequate water, sanitation, and hygiene (WaSH) facilities are currently acknowledged to improve education, health, income, and safety outcomes for women and girls, and have an impact on their daily wellbeing and status in their communities (J. J. W. Fisher, Sanitation & Report, 2006).

Fetching water also impacts the health of the water carrier. Qualitative studies have indicated that water carriers experience pain and feel exposed to risk of injury during water carriage (Geere, Cortobius, Geere, Hammer, & Hunter, 2018a). Direct health impacts have been reported, such as increased pain, fatigue, and stress. A study by Greere et al, found that typical water carrying methods impose physical loading with potential muscolosketal disorders and other related disabilities. Women and children also have reduced injury tolerance for physical loading through the cervical spine compared to men (J.-A. Geere et al., 2018), and in low-income and rural areas may be vulnerable to physical injury due to high levels of poverty, poor health and chronic disease (Pouramin, Nagabhatla, & Miletto, 2020). Little research has been conducted to investigate physical aspects of water carrying as it is performed by women and children. Most studies that investigate the health impact of physical loading are of male adult workers or are conducted in high income countries (Curti, Coggon, Hannerz, & Mattioli, 2016).

Water collection can also impact the mental health of those responsible for the task. A study in Kenya found the task to be a source of stress due to anxiety about returning home to take care of children, when no else is available for childcare (Henley et al., 2014). The effects of fetching water on women and girl's health are likely to be more pronounced in low- and middle-income countries where a greater proportion of people are engaged in physically demanding and informal work environments (Dupas & Miguel, 2017). Indirect health impacts also have been reported related to perinatal health and social vulnerability. These included serious health issues such as physical abuse and rape (Sommer, Ferron, Cavill, & House, 2014). Access to drinking water can reflect economic, political and social inequalities, especially as it is likely that marginalized groups suffer disproportionally from the negative economic and health impacts of fetching water (Steele, 2018).

Another consideration is whether conventional indicators such as distance walked to the source of water or time spent collecting water are appropriate when assessing the impacts of drinking water supply interventions on women. Narain *et al* advocate for examining how interventions influence gender relations more broadly. This shift from women to gender relations in the household may give a better assessment of the impacts of interventions (Narain, 2014).

The economic perspective of water focuses mainly on the women fetching and treating the water. Policy makers are concerned about economic growth and how women can be cultivated into being economic agents. The assumption is that if freed from the chore of fetching, treating and storing water, women will devote their time to income-generating activities (Asaba, Fagan, Kabonesa, Mugumya, & Water, 2013). However, these assumptions do not account for the difficultly of monetizing the value of women's unpaid work and the fact that having time does not necessarily lead to having access or the desire to participate in income-generating

activities (Cornwall, Harrison, Whitehead, & Change, 2007). Gender models that drive water security programs that view women as entrepreneurs or sole decision makers, fail to consider intra-household relationships and negotiations that give value to women's agency (Batliwala, 2007). Studies in Nampula, Mozambique have shown how water projects have increased women's participation in farming as they were able to collect water early and arrive at the farm less tired and on time to support their husbands (E. J. S. Van Houweling & resources, 2016). Another study in Kenya, found that time saved from improved water sources was used by women for catching up on sleep (Crow, Swallow, & Asamba, 2012). A study in rural Benin tested the hypothesis that funding public water supply will significantly decrease the time spent on water collection, and lead to increased labor force participation of women. They found that daily water collection times were reduced by 41 minutes but still took two hours after the installation of the public pump. Even though walking distances were reduced, there was still waiting time at the water source. The conclusion was that time savings are rarely followed by an increase in the labor supply of women. The economic value of the annual time savings was 1-2% of a rural households income (Gross, Günther, & Schipper, 2018).

Empowerment in the water sector also fails to address men's gender roles and leaves little space for considering local ideas of empowerment. Some studies have shown that men resist the freedom women have when the burden of water collection is lifted. Cases in South Asia especially suggest that men want to preserve the role of water collection for women because it keeps them busy and "out of trouble" (Mandara, Niehof, & van der Horst, 2017). In other cases, men were comfortable with the water intervention cutting down water collection time as it meant women could be at home where the men could supervise their behavior (Mitra & Rao, 2019).

Not having access to clean and safe water affect social groups differently depending on the resources and opportunities available to such groups (Rao & Pachauri, 2017). While, the responsibility of water collection, storage, and management at the domestic level falls upon women (C. B. Coulter, Kolka, & Thompson, 2004), men may support their wives in situations when the water is especially hard to obtain or requires considerable physical effort (A. J. H. Coles, 2009). The extent to which men help women in water collection, depends on the season, distance to the water source, health of the family, and family structure (E. Van Houweling, 2015). A study in Ghana looked at how men's work changes after domestic water projects were introduced. Arku et al, found that women were able to engage in income-producing activities after the completion of a large water supply project, but men also spent less time helping their wives with domestic chores (Arku, 2010).

Studies have also shown that water interventions can reinforce, rather than correct, existing social inequalities. This results in the poorest, who are often women, being excluded from access to water (Wallace et al., 2005). For example, in southeastern Turkey researchers found that while some people benefited from large-scale drinking water and irrigation development project, women, and the landless poor all experienced losses from the project (Harris, 2008).

A report by the World Bank (2017) declares, "water often reflects, and even reinforces gender inequality" and water-related interventions that balance gender relations can have a strong influence in furthering gender equality and inclusion overall (Das, 2017). Public health practitioners must ensure that their design of, and involvement in, water and sanitation services do not further contribute to this unpaid work, or lower women's ability to get paid work by requiring more hours spent at home or in the process of ensuring and securing clean water.

Gender Responsive Assessment Scale

According to the WHO, “Gender refers to the roles, behaviors, activities, attributes and opportunities that any society considers appropriate for girls and boys, and women and men” (int/gender-equity-rights/understanding/gender-definition/en/, 2017). Gender interacts with, but is different from, the binary categories of biological sex. Gender is also central to relationships between people and can mirror and predict the distribution of power between those individuals and within their relationships (Lind, 2018). These relationships, and therefore the correlating power imbalances, work at interpersonal, institutional and societal levels. At every level, gender is an important determinant of health and development (Merchant & Vidal, 2019). Therefore, gender must be taken into account in the development and implication of any service equity project such as provision of clean drinking water. At the strategic and programmatic levels, an increasing number of social and behavior change interventions recognize health behaviors are embedded in social and structural factors, including gender norms and inequalities that divide men and women economically in terms of resources and politically in terms of rights. Interventions may “integrate gender” with other social and behavior change activities, thus addressing gender along with individual factors (e.g. knowledge) and other social and structural factors.

The SDG targets related to water are unlikely to be achieved unless gender perspectives are integrated into programming and interventions. Gender mainstreaming is a way to assess “the implications for women and men of any planned action, including legislation, policies or programs, in all areas and at all levels” (Cairns, Workman, Tandon, & Culture, 2017). The gender mainstreaming strategy helps make women’s and men’s concerns and experiences an

integral dimension of the design, implementation, monitoring, and evaluation of policies (Van Eerdewijk & Davids, 2014).

Several tools have been developed to evaluate gender in programs and policies. The WHO Gender-responsive assessment scale (GRAS) is one such tool that was developed to assess programs and policies and to integrate the use of gender in programs (Men et al., 2013). GRAS provides a framework for understanding approaches to integrating gender and highlights the differences between ignoring and addressing gender considerations. The scale has five designations: gender-unequal, gender-blind, gender-sensitive, gender-specific, and gender-transformative (See Figure 1).

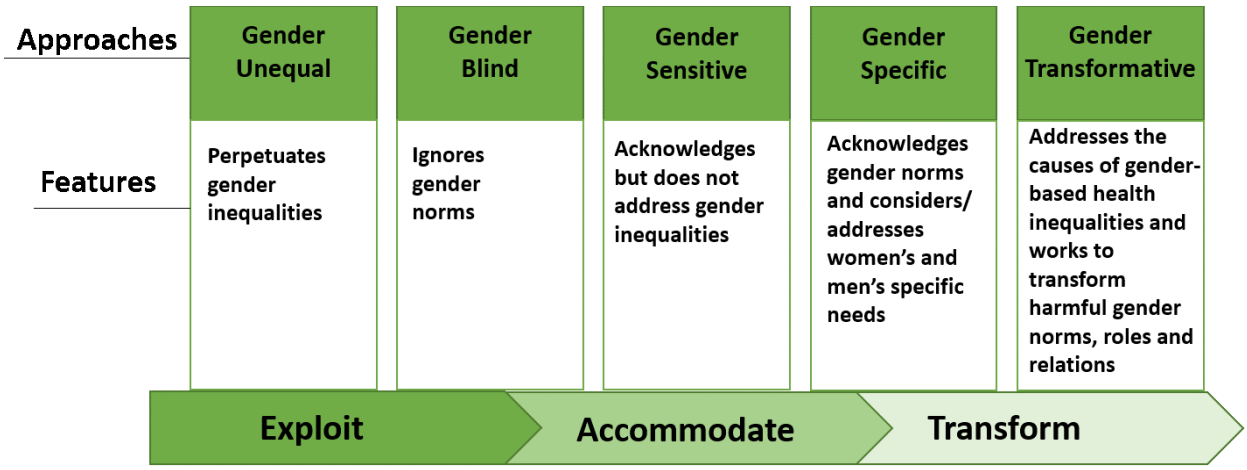

Figure 1: Gender Responsive Assessment Scale (GRAS) (World Health Organization, 2011)

Although gender mainstreaming has become common, gender is often superficially integrated into water-related projects (A. Coles & Wallace, 2020). In practice, gender quickly becomes apolitical and simply another bureaucratic hoop to leap through, instead of a commitment to social change (Cairns et al., 2017). Reviews of "gender-sensitive" water programs have revealed simple routines and checklists for including girls and women, without

meaningful effort to further the goals of equality and effectiveness (Elmendorf & Organization, 1990).The category of "women" is simply added on to, rather than integrated into, policy documents. For example, this was especially seen in a review of the gender approach work by the organization Water Aid, where the ideas of gender and women were erratically sprinkled throughout policy reports, but had few organizational policies that focused on gender and equity. Attention to gender relations and the social context is often bypassed in the water sector by equating gender to women (Wallace et al., 2005).Women are targeted in the water sector based on the premise that they form a singular and cohesive group (Cleaver & Values, 1998).

Integrating gender in water interventions could result in reduced caregiving burdens and better health outcomes, giving women more time for productive endeavors, education, and leisure (Devoto, Duflo, Dupas, Parienté, & Pons, 2012). If done in a manner that balances the gendered responsibilities of water and sanitation, WaSH inventions have the potential to further gender equality in an even broader sense (J. Fisher, Cavill, Reed, & Development, 2017). Economic and cultural norms are also significant in shaping how women spend their free time (Ilahi, Grimard, & Change, 2000). Time freed up from improved water access cannot be put into income generating activities unless those opportunities exist and are prioritized by women. There is a component of water system design that matters as well. A study in Senegal in 2012 found that small piped systems freed up women's time and enabled women to expand existing livelihood activities such as small commerce, gardening, and raising livestock. This finding can be attributed to the way the water systems were designed to facilitate a range of activities rather than simply provide water for basic needs. Water projects designed to serve the whole range of productive and domestic needs in a community have been found to be more gender equitable

than systems, such as handpumps, designed to deliver water only for basic needs (E. Van Houweling, 2015).

However, when interventions ignore power dynamics and the focus is limited to an isolated goal, the outcome will likely not be as much help to women and other marginalized groups. In these cases, the burden of achieving singular goals will fall to these groups, without any recognition of the time, work, and energy spent in the pursuit of success (Das, 2017).

Water Interventions

Strategies utilized by governmental and non-profit organizations to improve access, quantity, and water quality can be grouped into several categories. This section provides foundational knowledge on these types of water interventions.

Interventions to improve the microbiological quality of water are grouped into four categories:

- Physical removal of pathogens: including filtration, sedimentation or adsorption.
- Chemical treatment to kill or inactivate pathogens, commonly done with chlorine.
- Heat as a disinfectant treatment. For example, boiling or pasteurization. The use of ultraviolet (UV) rays can be used for solar disinfection.
- Combination of these approaches.

Water interventions can be implemented at multiple points along the supply chain, from source to consumer. Individuals can collect water directly from a source and then transport it home for storage and consumption. The safety of the water can be improved, and the level of access can be increased by introducing interventions to protect sources, storage, treatment, and distribution. In higher-income countries, drinking water is treated centrally at the source of supply and then distributed to consumers through a network of pipes. Drinking water can also be treated at the

point-of-use (POU) in consumers' homes, workplaces, and other spaces (Clasen et al., 2015). In the most recent work by Clasen *et al*, (2015), interventions addressing the microbial contamination of water at the point-of-use were found to be an important interim measures to improve drinking water quality until homes can be reached with safe, reliable, piped-in water connections (Clasen et al., 2015). POU interventions are widely used for low-income settings and include filtration, boiling, chlorination, and solar disinfection (Clasen et al., 2015).

A significant measure of the success of water interventions at household and community levels is the degree to which the project outcomes are sustained and enhanced after the project is completed. Sobsey (2002) argues that behavioral, educational, and participatory activities are essential elements of successful and sustainable introduction of water treatment technology (Sobsey, Water, & Organization, 2002). Toolkits like participatory hygiene and sanitation transformation (PHAST) published by WHO hold participatory learning at their core (Dumba, Kaddu, & Wabwire-Mangen, 2013). Community participation, and especially women's participation, has been promoted in the water sector as a path towards empowerment and more successful projects. Participation can be diluted to quantifiable indicators. In water interventions, examples of these indicators include number of people attending meetings or trainings, as well as monetary or labor contributions to a project. Participation in these cases means involvement in an externally conceived intervention where decisions have been made by external agents (E. Van Houweling, 2015).

Currently, no studies have evaluated how women and girls are engaged in water quality interventions and programs. Yet, women and girls are typically the targets for participation as necessary actors involved in intervention success, based on their role as the domestic water collectors and stewards. Studies have demonstrated that when women are invited to participate in

water initiatives, they generally occupy unpaid positions at the lowest level (Mandara, Niehof, van der Horst, & Studies, 2014). Water interventions also need an individual to perform a task, such as dispensing water, water, and storage. These time consuming responsibilities typically are unpaid and of little consequential value in determining gender equality and equity (Joshi & Fawcett, 2001). Water interventions can improve the quality and quantity of water supply but can also have an impact on gender and power relations both at the household and community levels. This can lead to greater gender equality in terms of women's decision-making and participation in local water management (Panda, 2006).

Conclusion

Diarrheal diseases resulting from unsafe drinking water contributes to almost 1.6 million deaths globally, a high burden of morbidity and mortality worldwide. In 2017, diarrheal disease was the cause of every tenth child's death (Ritchie & Roser, 2019). In addition to this health burden, there are challenging dynamics between water and gender. Globally, the responsibility of water collection, storage, and management at the household and community levels falls on women and girls (J. E. Coulter, Witinok-Huber, Bruyere, & Dorothy Nyingi, 2019) (Graham et al., 2016) (Sorenson et al., 2011). Over the last several decades interventions designed to improve drinking water have made strides in the areas of access and utilization, particularly with POU interventions. However, understanding how these interventions engage women remains unknown. In order to advance health, safety, and gender equality in global communities, there is a need to evaluate how women and girls are engaged in these water interventions.

Objectives

The purpose of this study is to examine how water interventions aimed at reducing diarrheal illness engage women and girls as necessary actors for the implementation of the intervention. This study will investigate how water interventions engage women and girls. Leveraging a previously published systematic review of water quality intervention trials, we investigate the following aims:

Aim 1: To understand what proportion of water interventions women, girls, boys, and/or men, as necessary actors for the interventions' success/functioning.

Aim 2: To classify the ways women and girls are engaged according to the WHO Gender Assessment Scale.

Chapter 3: Methods

3.1 Research Design

This study evaluated the ways in which water quality interventions aimed at reducing diarrheal disease engaged individuals (women, girls, boys, and men) to achieve intervention goals. The interventions considered were compiled as part of a Cochrane systematic review by Clasen *et al.*, (2015) *Interventions to improve water quality for preventing diarrhoea*.

We used the WHO Gender Responsiveness Assessment Scale to classify the ways women and girls specifically were engaged by the interventions included in the review. The purpose was a 'proof of concept' to see if, in an identified set of published literature, the framework could be applied as a tool for assessment of interventions and thus warrant future application, inclusive of more recent studies as well as studies on other types of water and sanitation interventions.

3.2 Article Eligibility

Clasen *et al* 2015 Cochrane review, *Interventions to improve water quality for preventing diarrhoea*, served as the source for the peer-reviewed published articles included in our analysis (Clasen et al., 2015). The review examined the published, peer-reviewed literature for cluster-randomized controlled trials (cluster-RCTs), quasi-randomized controlled trials (quasi-RCTs), and controlled before-and-after (CBAs) study interventions aimed at improving the microbiological quality of drinking water and lowering diarrheal incidence through November, 2014. The review was restricted to studies that directly explored the effects of water quality interventions, including point of use water treatment (chlorination) and filtration among others, on lowering diarrhea incidence. No additional search strings were used in literature databases as

the review was determined to be comprehensive and inclusive of all relevant water quality studies through 2014. Using this approach, we therefore did not conduct a systematic search to identify published peer-reviewed literature on water quality interventions.

After retrieving the peer-reviewed literature included in the review, we screened each article according to our inclusion and exclusion criteria, defined as follows:

Inclusion criteria:

- Studies that required individuals, or groups of individuals, to implement the intervention directly (i.e. point of use water filtration, maintaining the water filter, etc.)

Exclusion criteria:

- Studies that did NOT require individuals, or groups of individuals, to implement the intervention directly (i.e. point of use water filtration, maintaining the water filter, etc.)
- Dissertations and unpublished data

3.3 Analysis

3.3.1 Descriptive statistics of included studies

Data from each included study, including intervention type, geography, number of households engaged, etc., were extracted, compiled into an Excel database, and summarized (Microsoft, 2016).

3.3.2 Gender Identification of primary intervention actor(s)

To determine the proportions of interventions that engaged women, girls, boys, and/or men as necessary actors in the intervention, we identified the gender of the primary individual involved in the intervention (aim 1). The primary individual's gender was determined by words that were used in the article to describe the individual involved in the study. The gender of the primary actor was considered to be female if "woman", "mother", "caregiver", "caretaker", "female", and/or "daughter" was used. The gender of the primary actor was considered to be male if "male", "men" and "father" was used. Notably, for this characterization, we assumed the terms caregiver and caretaker referred to females. In the event none of these words were found, we did not assign a gender designation.

3.3.3 Identification and Classification of intervention activities according to the WHO Gender Responsive Assessment Scale

To understand the activities that individuals were expected to do as part of water quality intervention, we reviewed and documented the specific instructions that were given to individuals as described in each study. These were categorized into intervention-related

activities, which needed to be followed for the functioning of the interventions, (i.e. point of use water chlorination, changing water filters) and research-related activities, such as being interviewed or surveyed and keeping diarrheal records.

We classified the ways men and women were engaged in the interventions according to the Gender Responsiveness Assessment Scale (GRAS) (aim 2). We used the GRAS criteria **(Figure 1)** to evaluate which of five categories best describes the type of engagement for each intervention: gender-unequal, gender-blind, gender-sensitive, gender-specific, and gender-transformative.

Gender-unequal. For all studies that explicitly targeted a gender to perform a task, such as "mother", "woman" or "caregiver" or "caretaker" (which was assumed to be female), these studies were assigned to the category of *gender-unequal.* An example of an intervention categorized as gender-unequal would be one in which the female head of household or the eldest daughter were specifically targeted and given instructions on washing produce and utensils used by the household as part of the intervention, simply because they are female.

Gender-blind. For roles that were undefined and for which the power balance of the roles was not considered, *gender-blind* was assigned to the study. An example of a gender-blind categorization would be an intervention that involved field staff visiting households to collect and distribute diarrheal recall diaries, without indicating specifically who in the household was responsible for keeping the diaries.

Gender-sensitive. In studies that specifically mentioned the unequal nature of roles that women and girls were assigned to but did not offer remedial action, *gender-sensitive* was used. An example of a gender-sensitive categorization would be an intervention in which field staff

acknowledge that girls and women bear the responsibility for completing the diarrheal diaries but no effort was made to shift this responsibility to other adults in the household.

Gender-specific. Studies that acknowledged the different norms and roles for women and men and how they influence access to resources were assigned as *gender-specific*. An example of a gender-specific categorization would be an intervention that included an awareness campaign illustrating the disproportionate labor women and girls do to maintain safe water for the household.

Gender-transformative. Studies that considered gender norms, roles, and relations and included ways to transform harmful gender norms and roles were assigned as *gender-transformative.* An example of a gender-transformative categorization would be intervention materials that depicted individuals of all genders engaging in collecting, treating, and storing safe water.

We tallied interventions that were gender-unequal, gender-blind, gender-sensitive, gender-specific and, gender-transformative, in order to assess the proportion of interventions for each level of the scale. We also assessed the proportion of interventions for which a gender was explicitly identified among rural versus urban study sites and for adults versus children.

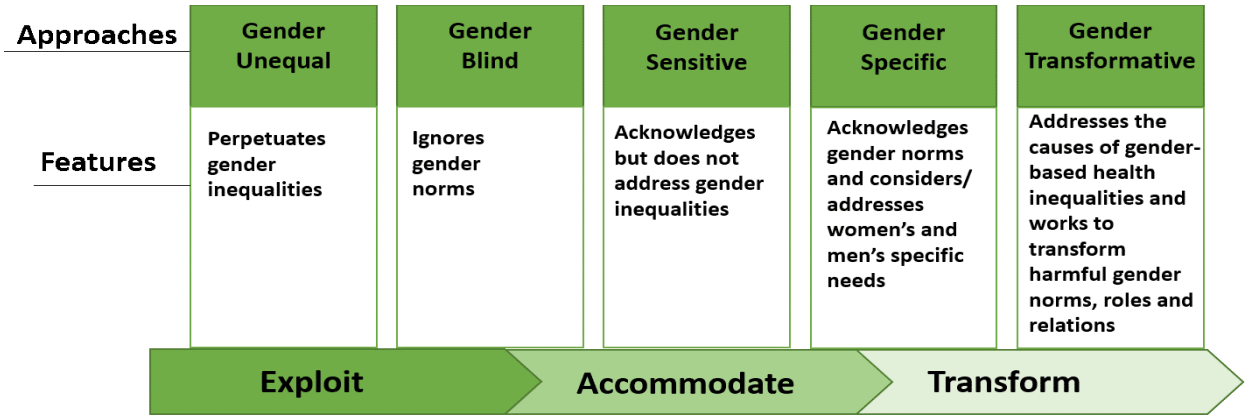

Figure 1. WHO Gender Responsiveness Assessment Scale (GRAS) (2).

Chapter 4: Results

4.1 Articles included in analysis

The Clasen *et al*., systematic review included 52 articles. Among these 52 articles, four were dissertations and one article was in Chinese, which were omitted from this review. Of the 47 remaining articles, one article was excluded upon full review as it did not require an individual to be engaged in the water quality intervention. Ultimately, 46 (81%) articles were determined to be eligible for inclusion in our analysis (Figure 1).

4.2 Study and Intervention Characteristics

We characterized the included studies by geographic region, urban or rural setting, and target population (Table 1). Notably, most of the studies were conducted in Africa (20, 43.5%), followed by the Americas (15, 32.6%). Fewer studies were conducted in the Eastern Mediterranean region (5, 10.9%), the Western Pacific region (3, 6.5%), South-east Asia (2, 4.3%), and Europe (1, 2.2%). The majority of the studies were undertaken in lower-middle or low-income countries as defined by the World Bank criteria cite; however, five studies were conducted in high income settings, specifically the United States, Australia, and Saudi Arabia. A majority of the interventions took place in rural areas (31, 67.4%), whereas only 10.9% were in urban settings. Other studies were conducted in peri-urban environments (3, 6.5%) or refugee camps (2, 4.3%), and 10.9% of the studies were involved in multiple settings.

Study designs and interventions varied (Table 2). Forty of the studies were Cluster Randomized Control Trials (CRT), one was a quasi-Randomized Control Trial (RCT), and five were Community-based Alternate (CBA) studies. Combined, a total of 17,613 households were analyzed across all interventions.

Filtration represented the most common water quality intervention (37%), followed by chlorination (15.2%), solar disinfection (13%) infrastructure-based interventions (13%), chemical disinfection (10.9%), and flocculation (10.9%). Forty two (91.3%) targeted only adults to perform the required intervention, whereas three of the studies targeted only children (6.5%). Only one study engaged both children and adults in the primary water quality intervention (2.2%). Mothers were targeted by 44% of the interventions and female caregivers by 37% of the interventions. Women (non-caregiver and non-mother) were targeted by 26% of the interventions. Two percent of the interventions targeted the eldest daughter of the household specifically. Seven percent of the interventions targeted male members of the household.

Additional details such as setting, study design, intervention and number of households engaged for each study regarding the 46 studies which met the inclusion criteria of this analysis can be found in Table 2.

4.3 Intervention Activities

We reviewed all water interventions, looking specifically at the characterization of behaviors and instructions assigned to target individuals across all interventions. This characterization allowed us to determine the burden of work individuals were expected to do for each of the studies (Table 5). Across all (100%) interventions, participants were expected to perform direct intervention activities (100%). Intervention activities such as using and maintaining a filtration device, using a UV tube system to disinfect water, and providing manual labor to build the intervention infrastructure. For intervention-related activities, examples of these additional instructions/behaviors include: specific ways to dispose of feces, attending educational sessions of hygiene and health education, instructional sessions regarding the maintenance of the

intervention tool, and paying into the intervention by purchasing the intervention tool (i.e. filtration device).

4.4 Research Activities

In addition to the intervention activities, in 46 (100%) studies, household members in both study intervention and control arms were asked to participate in research-related activities. It was common to require participants to respond to questionnaires on diarrhea symptoms of all family members in the household, or to request that they maintain diarrheal recall diaries. For instance, among all solar disinfection interventions, all participants were asked to keep a diarrheal recall diary. Diarrhea prevalence was the primary outcome of the interventions and diarrheal diaries are an established and validated methods of quantifying these data, paired with survey data on hygiene knowledge and behavior. The proportion of interventions that expected participants to engage beyond primary water treatment research activities was relatively high (80%). Also, 11 of the 46 studies conducted unannounced visits to collect drinking water samples from households in both intervention and control arms, and to check intervention adherence through water testing (Boisson, Schmidt, Berhanu, Gezahegn, & Clasen, 2009; Chiller et al., 2006; Crump et al., 2005; Doocy, Burnham, & health, 2006; Luby et al., 2004; Mausezahl et al., 2009; Mengistie, Berhane, & Worku, 2013; Opryszko et al., 2010; Patel et al., 2012; Reller et al., 2003; Roberts et al., 2001).

4.5 Characterization of interventions and research activities according to the WHO Gender Assessment Scale

Assessment of how interventions engaged individuals using the WHO gender assessment scale are shown in Tables 3 and 4. Overall, 100% of the interventions were classified as gender unequal (63%) or gender blind (37%); none of the interventions were classified as gender sensitive, gender neutral or gender transformative (Table 4).

Interventions that were classified as gender-unequal explicitly mentioned women, mothers, caregivers, and/or eldest daughter in the household to be responsible for the intervention activities. For example, in some studies, mothers are specifically asked to attend sessions on hygiene education, as described in Lule *et al.*, (2005). In other studies, female household members were given the sole responsibility for treating the household water supply (Quick et al., 2002).

Interventions that were classified as gender-blind did not explicitly specify the gender of the individuals expected to do the intervention activities and intervention practitioners did not consider who would be responsible for the work according to societal and cultural gender norms. The work took several forms, depending on the intervention. For example, in Jain et al (2010), participants were expected to chlorinate the drinking water and to be attend hygiene sessions in the households to intervention staff every 3-4 days. However, the household members performing these actions were not reported by the authors. In other studies, the non-specific term “family members” was used to describe the individuals responsible for performing intervention actions or behavior change, and thus these studies were also classified as gender-blind.

Fig 1. Flow diagram of publications considered for this review

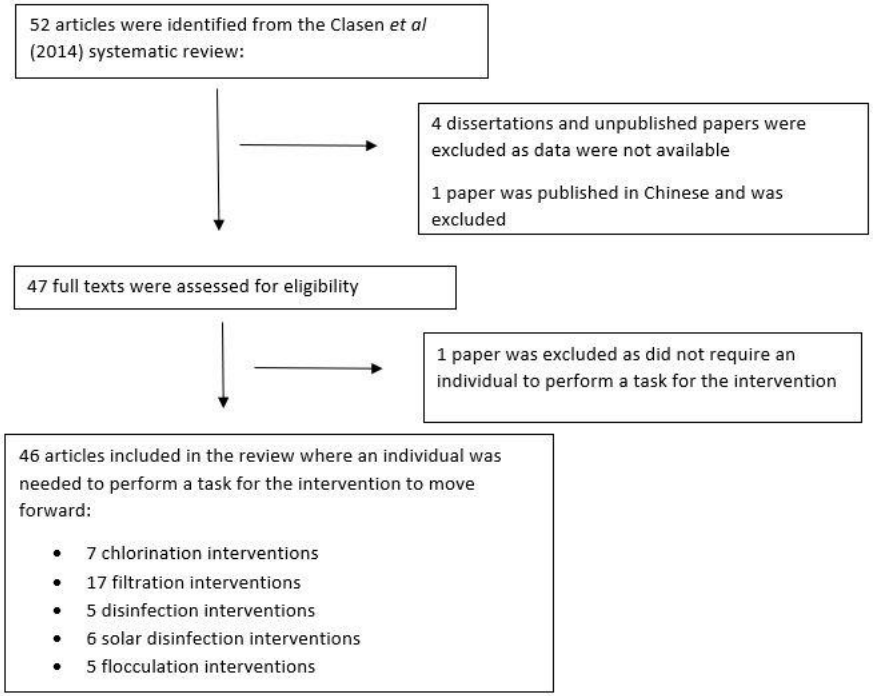

Table 1. Characteristics of water quality studies included in analysis (N=46)

Location	N (%)
Africa	20 (43.5%)
Americas	15 (32.6%)
Eastern Mediterranean	5 (10.9%)
Western Pacific	3 (6.5%)
South-east Asia	2 (4.3%)
Europe	1 (2.2%)
Setting	
Urban	5 (10.9%)
Peri-urban	3 (6.5%)
Rural	31 (67.4%)
Multiple settings	5 (10.9%)
Refugee camps	2 (4.3%)
Intervention Type	
Chlorination	7 (15.2%)
Filtration	17 (37%)
Disinfection	5 (10.9%)
Solar disinfection	6 (13%)
Flocculation	5 (10.9%)
Infrastructure	6 (13%)
Study Type	
CRT	40 (87%)
RCT	1 (2%)
CBA	5 (11%)
Household person engaged in intervention activities	
Adults	42 (91.3%)
Children	3 (6.5%)
Both	1 (2.2%)

Table 2. Characteristics of water interventions

Study ID	Study design	Intervention type	Setting	Total number of households targeted in the study (N)
Jain *et al* (2010)	CRT*	Chlorination	Rural	240
Jensen *et al* (2003)	CBA**	Chlorination	Rural	226
Lule *et al* (2005)	CRT	Chlorination	Rural	392
Kirchhoff *et al* (1985)	CRT	Chlorination	Rural	20
Boisson et al (2013)	CRT	Chlorination	Rural and Urban	2163
Mahfouz et al (1995)	CRT	Chlorination	Rural	171
Mengistie et al (2013)	CRT	Chlorination	Rural	573
Gruber *et al* (2013)	CRT	Disinfection	Rural	444
Luby et al (2004)	CBA	Disinfection	Urban	302
Quick RE et al (2002)	CBA	Disinfection	Rural and Peri-urban	260
Quick et al (1999)	CRT	Disinfection	Peri-urban	127
Opryszko et al (2010)	CRT	Disinfection	Rural	553
Lindquist *et al* (2014)	CRT	Filtration	Peri-urban	904
Abebe *et al* (2014)	CRT	Filtration	Rural	72
Boisson et al (2010)	CRT	Filtration	Rural	240
Brown et al (2008)	CRT	Filtration	Rural	180
Clasen et al (2004)	CRT	Filtration	Rural	60
du Preez et al (2008)	CRT	Filtration	Rural	115
Fabiszweski et al (2012)	CRT	Filtration	Rural	176
Colford et al (2005)	CRT	Filtration	Urban	50
Colford et al (2002)	CRT	Filtration	Urban	80
Rodrigo et al (2011)	CRT	Filtration	Urban	300
Tiwari et al (2009)	CRT	Filtration	Rural	59
Colford et al (2009)	CRT	Filtration	Urban	714
Stauber et al (2012)	CRT	Filtration	Rural	189
Boisson et al (2009)	CRT	Filtration	Rural	313

Stauber et al (2009)	CRT	Filtration	Semi-Rural and Urban	167
Clasen et al (2004)	CRT	Filtration	Rural	50
Clasen et all (2005)	CRT	Filtration	Rural and Urban affected by conflict	140
Crump et al (2005)	CRT	Flocculation	Rural	605
Chiller et al (2006)	CRT	Flocculation	Rural	514
Luby et al (2006)	CRT	Flocculation	Rural	1337
Doocy et al (2006)	CRT	Flocculation	Camps for displaced persons	400
Reller et al (2003)	CRT	Flocculation	Rural	492
Kremer et al (2011)	CRT	Infrastructure	Rural	1384
Gunther et al (2013)	CRT	Infrastructure	Rural	711
Roberts et al (2001)	CRT	Infrastructure	Refugee camp	240
Patel et al (2012)	CRT	Infrastructure	Rural	300
Alam et al (1989)	CBA	Infrastructure	Rural	623 children
Gasana et al (2002)	CBA	Infrastructure	Rural	150 children
Mäusezahl et al (2009)	CRT	Solar disinfection	Rural	225
McGuigan et al (2011)	CRT	Solar disinfection	Rural	365
Conroy et al (1999)	Quasi - RCT	Solar disinfection	rural	140
du Preez et al (2010)	CRT	Solar disinfection	Peri-urban	649
du Preez et al (2011)	CRT	Solar disinfection	Peri-urban and rural	765
Conroy et al (1998)	CRT	Solar disinfection	rural	206

**CRT is Clusted Randomized Control Trial*

***CBA is Community Based Alternate*

Table 3. Roles associated with study interventions, household members responsible, and classification according to the WHO gender scale

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
Chlorination Interventions					
Jain *et al* (2010)	1.Use of NaDCC tablets to treat drinking water 2. Use of provided container to treat correct amount of water	Report diarrheal episodes every 3-4 days over a 12 week period (I^ and C***)	None described	Gender blind	Does not specify who in the household is responsible for treating water and, be present for interviews on recall for diarrheal episodes
Jensen *et al* (2003)	Chlorinated drinking-water from water-supply system	Report episodes of diarrhea with field worker weekly over seven months (I and C)	Mother	Gender unequal	Mother is specifically asked to share diarrheal episodes
Lule *et al* (2005)	1.Hypochlorite treatment of household water and safe storage 2. Attend basic hygiene education sessions	Report episodes of diarrhea weekly over three months (I and C)	None described	Gender blind	Does not specify who will store the safe water and attend sessions on hygiene education
Kirchhoff *et al* (1985)	Hypochlorite treatment of household water and share process with CHW	Report GI illness three times a week to field workers over nine weeks (I and C)	Mother	Gender unequal	Mothers are expected to make time three times a week to meet with field staff

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
Boisson et al (2013)	Use of dichloroisocyanurate tablets to purify water. Adherence to the intervention was assessed by asking householders if they had treated their children's drinking water and by testing it for RFC. If the caregiver replied that the child's drinking water was treated, she was asked which method was used.	At each monthly visit over 12 months, the mother or primary caregiver was asked if her child had been absent on any given day of school during the previous 5 days of school (I and C)	Caregiver and mother	Gender unequal	Caregiver and mothers are asked to verify how household water was purified and, offer child's weekly school attendance details
Mahfouz et al (1995)	"families" used packets to chlorinate water	Stool samples were collected during monthly interviews over a 6 month period (I and C)	None described	Gender blind	Mentions that families will chlorinate the water but does not specify which individual would complete the activity
Mengistie et al (2013)	Disinfect water with bleach (sodium hypochlorite), main	1.Complete weekly diarrheal recall diary for five months (I and C) 2. Compliance of the intervention was assessed on two unannounced and regular weekly visits using free residual chlorine tests	Caregiver, mother and women	Gender unequal	Women, caregivers and mothers are targeted as sources to complete diarrheal diaries and to disinfect HH water

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
Disinfection Interventions					
Gruber *et al* (2013)	Use UV tube system to disinfect water and explain process of using drinking water in household	1. Weekly diarrheal recall by interview over 6 months (I and C) 2. Samples of drinking water were collected during each visit	Caregiver	Gender unequal	Caregivers are targeted as sources to complete diarrheal diaries and disinfect water
Luby et al (2004)	Use of hypochlorite to treat drinking water, Use of provided water vessel.	Field workers visited each participating house unannounced at least weekly to provide information on intervention and collect household diarrheal information over 6 months (I and C)	Caregiver, mother and women	Gender unequal	Caregivers, mothers and women are targeted as sources to complete diarrheal diaries and disinfect water. Field staff also visit the household regularly to check on mothers.
Quick RE et al (2002)	Attend trainings on how to flocculate water, Purchase special water vessels and disinfectant	Weekly active diarrhea surveillance (I and C), biweekly water testing, and a follow-up survey were conducted in a three month span	Caregiver, mother and women	Gender unequal	Caregivers, mothers and women are targeted as sources to complete diarrheal diaries and attend trainings to flocculate water

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
Quick et al (1999)	Treated water, which included drinking, handwashing, cleaning utensils and washing produce. Once a week, community health volunteers distributed containers with freshly prepared disinfectant to each intervention household, removed old containers, and used the labels on the special vessels to reinforce messages about proper use of the disinfectant and vessels and remind participants of different applications for treated water	1. Weekly diarrhea recall by interview of the female head of household or eldest daughter over 4 months (I and C) 2. Collect rectal swabs for individual experiencing diarrhea in household, weekly for 4 months (I and C) 3. Monthly visits for six months to survey water-handling practices, test storage and source water quality (I and C)	Women and eldest daughter	Gender unequal	Women and eldest daughter in the household are responsible for treating HH water and offer weekly diarrheal updates
Opryszko et al (2010)	Disinfect water and use for drinking, cooking, etc.	Information from the primary adult female caregiver was sought as the most reliable source of information on diarrhea occurrence and water handling within the household, twice weekly over one year (I and C)	Caregiver, and women	Gender unequal	Women were responsible for all activities related to the intervention
Filtration Interventions					

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
Lindquist *et al* (2014)	1.Use and maintain the filter, attend weekly training on use and maintenance, education on food preparation 2. Attend basic lessons on diarrheal transmission, prevention, and treatment of dehydration/feed sick child	Diarrheal recall for two weeks over four months (I and C)	Caregiver	Gender blind	Caregivers were responsible for all intervention activities
Abebe *et al* (2014)	Use and maintain the filter, attend weekly training on use and maintenance, and overall hygiene	Kept weekly diarrhea recall diary over 12 months and data was cross checked over weekly phone calls, responded to intermittent hygiene survey (I and C).	None described	Gender blind	Does not specify who in the household is responsible for treating water and, be present for interviews on recall for diarrheal episodes
Boisson et al (2010)	Use and maintain the filtration device	1.Female head of household or primary care giver of young children were interviewed once each month over a 12-month period for diarrheal recall (I and C). 2. Filters (even placebos) were monitored monthly during household visits (I and C)	Caregiver and female head of household	Gender unequal	Females members of the household are responsible for intervention activities

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
Brown et al (2008)	Filter use and maintenance	1.The primary caregiver was asked to collect a sample of water in a sample collection container as if it were a household drinking cup (I and C) 2. Biweekly, 7-day binary recall of diarrheal disease for herself and all members of the household, beginning with the day of the interview over 22 weeks (I and C)	Caregiver	Gender blind	Does not specify who in the household is responsible for treating water and, be present for interviews on recall for diarrheal episodes
Clasen et al (2004)	Filter use and maintenance. Intervention group told to use filtered water for drinking, cooking, and washing fruits, vegetables, plates and cooking utensils	1.Diarrheal recall diary in last 7 days at five monthly visits (I and C) 2.Water samples were collected from each household monthly for five months (I and C)	Female head of household	Gender unequal	Female members of the households are responsible for intervention activities
du Preez et al (2008)	Each household member instructed how to assemble, fill and clean filters. Told not to open or clean lower vessel.	Daily pictorial sheet recording diarrhea episodes and distinguishing between bloody and non-bloody diarrhea over 6 months (I and C)	Caregiver	Gender blind	Does not specify who in the household is responsible for treating water and, be present for interviews on recall for diarrheal episodes

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
Fabiszweski et al (2012)	Use and maintenance of plastic housing BSFs. Attend education sessions on hygiene and sanitation	1. At each bi-weekly visit, the mother or primary caregiver was asked if her child had been absent on any given day of school during the previous 5 d of school over 11 months. Blinding - On the last follow-up visit the mother or primary caregiver of the child was asked to guess whether they had been receiving the active tablet or placebo (I and C). 2. Primary respondent responded to survey on water management practices (I and C) 3. Weekly diarrheal recall interviews were conducted over 11 months (I and C)	Caregiver	Gender blind	Mothers and caregivers are expected to offer child's weekly school attendance details
Colford et al (2005)	Use and maintain the filtration device	1.Daily recording in a diary any nausea, vomiting, abdominal cramps, cough, and fever for two weeks. (I and C) 2. Every two weeks recorded water	None described	Gender blind	Does not specify who in the household is responsible for treating water and, be present for interviews on recall for diarrheal episodes

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
		consumption (self-report) (I and C) 3. Every 2 weeks for 16 weeks to report on questionnaire if they thought they had active device or not and water consumption (I and C)			
Colford et al (2002)	Use and maintain the filtration device	1. Daily diary record if household members had nausea, vomiting, diarrhea, abdominal cramps, cough, and fever (I and C). 2. Every 2 weeks for 16 weeks to report on questionnaire if the HH thought they had active device or not (I and C)	None described	Gender blind	Does not specify who in the household is responsible for treating water and, be present for interviews on recall for diarrheal episodes
Rodrigo et al (2011)	Use and maintain the filtration device	One adult member of each household was designated as the reporting participant and was responsible for ensuring completion of a weekly health diary for each participant for 12 months. This involved recording symptoms of diarrhea, vomiting, nausea, abdominal	None described	Gender blind	Does not specify who in the household is responsible for treating water and, be present for interviews on recall for diarrheal episodes

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
		pains, and fever (I and C)			
Tiwari et al (2009)	Technicians instructed BSF mothers on filter maintenance using the wet harrowing method to restore flow rates. Intervention households were advised to use BSF treated river water in place of untreated river water for all domestic purposes, including drinking, bathing, laundry, washing clothes, watering animals, etc.	1. Households were visited once a month to administer a questionnaire on reported diarrhea symptoms of all children (≤15 years) and adults during the preceding week (I and C). 2. Weekly diarrheal diaries were collected for 6 months (I and C)	Mother	Gender unequal	Females members of the household are responsible for intervention activities
Colford et al (2009)	Use countertop water filtration and UV device	Record daily occurrences of illness in health diaries and mail dairy monthly to research team (I and C)	Women	Gender unequal	Females members of the household are responsible for intervention activities

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
Stauber et al (2012)	Maintain filter and attend health and hygiene lessons	1.Contribute $10 for installation and then use plastic BSF for water. As a result, nine households in selected intervention villages did not receive the plastic BSF. 2. bi-weekly reporting of diarrhea in the last 7 days (I and C)	Caregiver and mother	Gender unequal	Females members of the household are responsible for intervention activities
Boisson et al (2009)	Trained on how to use and clean the personal water treatment device (filter)	1.Female head of households were visited fortnightly and asked to report any episode of diarrhea during the previous week over 5 months (I and C) 2. Unannounced household visits were conducted to take water samples (I and C)	Caregiver and female head of household	Gender unequal	Mother and caregivers were trained on using the filtration device. Fortnightly interviews were also conducted with the same population
Stauber et al (2009)	Use and maintain filter	1. Weekly diarrheal diary for four months (I and C) 2. Bi-weekly water samples were collected from the household for a year (I and C) 3. Weekly household surveys on water management practices (I and C)	Caregiver	Gender blind	Does not specify who in the household is responsible for treating water and, be present for interviews on recall for diarrheal episodes

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
Clasen et al (2004)	Households received gravity water filter system. They assembled the filter and were instructed on filling, using, and cleaning system.	1. Weekly diarrheal recall every 6 weeks (I and C) 2. Collect drinking water sample (I and C)	None described	Gender blind	Does not specify who in the household is responsible for treating water and, be present for interviews on recall for diarrheal episodes
Clasen et al (2005)	Use and maintain ceramic filtration device for drinking, cooking, cleaning utensils, to clean the candle when water rate slowed and to not open the lower vessel for any reason and only access water through tap	1. Weekly diarrheal recall every 6 weeks (I and C) 2. Collect drinking water sample (I and C)	None described	Gender blind	Does not specify who in the household is responsible for treating water and, be present for interviews on recall for diarrheal episodes
Flocculation Interventions					
Crump et al (2005)	To treat water with flocculant-disinfectant sachets or 1% sodium hypochlorite in stored drinking water (actual directions not in study)	1.Field workers visited the mother participating compounds weekly and used a standardized questionnaire to record the presence or absence of diarrhea and any deaths during the seven days since the last visit for each person. Diarrhea in children was usually defined by the mother (I and C). 2.Field workers administered	Mother	Gender unequal	Mothers were targeted weekly to share diarrheal incidents and deaths, and asked to seek care for family members at a health facility with severe diarrhea. They were also surveyed twice during the intervention on knowledge and attitudes about the intervention

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
Chiller et al (2006)	Instructions on flocculation (participants to decant the water through a flannel cloth into the storage vessel and to discard the residue remaining in the preparation vessel somewhere out of reach of animals and children)	standardized questionnaires to assess the mothers' knowledge of and attitudes towards the interventions during the fifth and 15th week of the study (I and C). 3. Unannounced visits every month to collect drinking water samples (I and C) Field workers urged mothers to seek care at a community health facility for any family member with severe diarrhea. 1.Weekly diarrheal recall by the mother for 13 weeks (I and C) 2. Field workers visited households weekly to administer surveys on water use and management (I and C) 3. Unannounced visits in weeks 3, 6 and 10 after the study, to collect drinking water samples (I and C)	Mother and women	Gender unequal	Mother and women were targeted to completed a weekly diarrheal recall diary and were given instructions on flocculation

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
Luby et al (2006)	1.Attend neighborhood meetings with info on health problems from contaminated water and instructions on how to use interventions assigned, 2. Hypochlorite treatment, soap with handwashing, or flocculent-disinfectant treatment.	1.Weekly diarrheal report by the mother over 6 months (I and C) 2.	Caregiver and mother	Gender unequal	Females members of the household are responsible for intervention activities
Doocy et al (2006)	Household treatment of water with flocculant-disinfectant product	1.Mother or female head of household answered weekly questionnaire to record presence of diarrhea for each household member over 12 weeks (I and C) 2.Intervention households received unannounced weekly water testing visits	Caregiver and mother	Gender unequal	Females members of the household are responsible for intervention activities

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
Reller et al (2003)	1. Household treatment of water with flocculant-disinfectant product 2. Field workers provided packets of oral rehydration solution and instructions for their use to all participating families, including controls. Field workers urged mothers to seek care at a community health post for any family member with persistent diarrheal symptoms	1. Participants given flocculant-disinfectant retained the empty sachets after use. So, the field workers could collect and count the empty and unused sachets. 2. Field workers administered standardized questionnaires to assess mothers' knowledge of and attitude towards the interventions one week, one month, three months, and six months after the interventions were distributed (I and C). 3.Unannounced weekly water collection and testing was conducted (I and C)	Mother	Gender unequal	Females members of the household are responsible for intervention activities
Infrastructure Interventions					
Kremer et al (2011)	Provide manual labor to build infrastructure. routine maintenance of spring protection (patching concrete, cleaning catchment area, cleaning drainage ditches)	1. A one-time household surveys including diarrhea in children. The household survey gathered baseline information about child diarrhea and anthropometrics,	Mother	Gender unequal	Females members of the household are responsible for intervention activities. The target survey respondent was the mother of the youngest child living in household.

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
		mothers' hygiene knowledge and behaviors (handwashing), household water collection and treatment behavior, and socioeconomic status (I and C)			
Gunther et al (2013)	1.Use of provided plastic or clay water storage containers 2. Avoid hand contact with drinking water and collect water from improved water sources only	1. Household member gives a one-time report on diarrhea for themselves and children in the house four weeks preceding an interview (I and C) 2. Water samples were collected monthly for 18 months (I and C)	None described	Gender blind	Does not specify who in the household is responsible for treating water and, be present for interviews on recall for diarrheal episodes
Roberts et al (2001)	Members of the intervention households were taught to add chlorine solution to each newly collected container of water. Because water was dispensed through a tap on the container, neither hands nor utensils could be immersed in the chlorinated water. thereby preventing recontamination.	1. Twice a week diarrheal recall interviews were asked of a HH rep. In a brief interview using standardized questions, interviewers recorded occurrences of diarrhea and dysentery reported by an adult member of the household as well as the age and sex of the affected individuals (I and C) 2. Water samples	None described	Gender blind	Does not specify who in the household is responsible for treating water and, be present for interviews on recall for diarrheal episodes

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
		were collected weekly for 10 weeks during unannounced visits (I and C)			
Patel et al (2012)	Use of handwashing station after visiting latrines and drinking from treated water station in classroom	1.Bi-weekly reports of diarrhea through interviews over 9 months 2. Students in grades 4 through 8 were interviewed about water treatment knowledge and behaviors (I and C) 3. Unannounced visits were conducted to test drinking water for residual chlorine (I and C). Participants were not informed of the chlorine status of their drinking water.	Mother and child	Gender unequal	Females members of the households are responsible for intervention activities

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
Alam et al (1989)	Maintain hand pump and attend weekly health education lectures for two months	Male Health Assistants visited households every week to collect household diarrheal information (I and C)	Women	Gender unequal	Women were responsible of maintaining the hand pump and attend education lectures on diarrheal management. Mothers and other female household members were targeted on awareness around diarrheal disease.
Gasana et al (2002)	Maintaining the water pump and use water from communal tap (fitted with filtration device)	1.Weekly diarrheal recall was done by the mother and women in the household (I and C) 2.Water samples were collected twice a week over a 3-month period (I and C) 3. One-time samples of feces were collected from children in the household (I and C) 4.An ongoing monthly survey over 15 months to collect information on demographic, social and agricultural changes and water transportation.	Caregiver, mother and women	Gender unequal	Caregivers, mothers and women kept a diarrheal recall diary and were expected to maintain the water pump
Solar disinfection Interventions					

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
Mäusezahl et al (2009)	Expose water-filled plastic bottles for at least 6 hours to sunlight using demonstrations, role play, and videos	1. Mothers or closest caretakers kept a 7-d morbidity diary recording daily any occurrence of diarrhea, fever, cough, and eye irritations in study participants over eight weeks (I and C). 2.Community-based field workers visited households weekly unannounced to collect the health diaries, and supervisors revisited an average 7% of homes (I and C). Discrepancies between supervisors and community-based field workers' records were clarified during a joint home revisit. Child exposure risks were also assessed by community-based staff interviewing mothers once during baseline and twice during the 1-y follow-up (I and C).	Caregiver and mother	Gender unequal	Caregivers and mothers are instructed to disinfect water, keep diarrhea diaries and be interviewed by staff

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
McGuigan et al (2011)	Instructions on solar disinfection. At the time of diary collection, intervention group caregivers were asked (i) whether they were using SODIS and (ii) whether it was possible to collect a water sample from the SODIS bottle that was in use	1.Diarrheal incidence was recorded daily for both control and test children using a pictorial daily diarrhea diary that was completed by the caregiver for each child and collected on a regular two week cycle over 12 months (I and C).12. Water samples were collected every 3 months over a year (I and C)	Caregiver	Gender blind	Does not specify who in the household is responsible for treating water and, be present for interviews on recall for diarrheal episodes
Conroy et al (1999)	Participants were given two 1.5 L bottles and told to keep in direct sunlight (on roof of hut) all day, place on roof at dawn, and wait until midday to give water to child under 6	1. Every two weeks on 26 occasions, mothers were asked to report episodes of diarrhea in children (I and C). 2. Drinking water samples were collected every two weeks on 26 occasions (I and C)	Mother	Gender unequal	Females members of the household are responsible for intervention activities
du Preez et al (2010)	Solar disinfection of drinking water	1.Completion of pictorial diarrheal diaries every month for a year (I and C) 2. Water sampling visits were carried out every 3 months for a year (I and C)	Caregiver and mother	Gender unequal	Females members of the household are responsible for intervention activities

Study ID	Roles associated with the intervention(s)		HH member assigned the role	Classification	Justification
	Actions/behaviors of HH member needed for success of intervention ("Intervention activities")	**Expected actions/behaviors of HH member as part of research activities ("Research activities")**			
du Preez et al (2011)	Solar disinfection of drinking water	1. Pictorial diarrhea diary, recorded daily and collected every two weeks for 17 months (I and C) 2. Water sampling visits were carried out every 3 months for 17 months (I and C)	Caregiver and mother	Gender unequal	Females members of the household are responsible for intervention activities
Conroy et al (1996)	Solar disinfection of drinking water by children – leave the bottle on roof of hut (I) and indoors in the shade (C)	Every 2 weeks for 12 weeks mother reported on diarrhea of children in household (I and C)	Mother, women,and children	Gender unequal	Mothers and caregivers are expected to disinfect water and offer diarrheal recall

^*I is Intervention*

****C is Control*

Table 4. Primary interventions types by gender scale classification and targeted individuals

Intervention	Gender scale		Individuals engaged in the implementation of interventions					
	Gender Unequal	**Gender Blind**	**Caregiver**	**Mothers**	**Women**	**Eldest Child**	**Males**	**Total**
All Intervention Types	**29 (63%)**	**17 (37%)**	**20 (37%)**	**19(44%)**	**13 (26%)**	**1 (2%)**	**3 (7%)**	
Chlorination	4 (57%)	3 (43%)	2 (29%)	4 (57%)	1 (14%)	0 (0%)	0 (0%)	7
Filtration	6 (35%)	11 (65%)	8 (47%)	1 (6%)	4 (24%)	0 (0%)	2 (12%)	17
Flocculation	5 (100%)	0 (0%)	2 (40%)	4 (80%)	1 (20%)	0 (0%)	0 (0%)	5
Infrastructure	4 (67%)	2 (33%)	1 (17%)	3 (50%)	2 (33%)	0 (0%)	0 (0%)	6
Disinfection	5 (100%)	0	4 (80%)	2 (40%)	4 (80%)	1 (20%)	1 (20%)	5
Solar disinfection	5 (86%)	1 (17%)	4 (67%)	5 (83%)	1 (17%)	0 (0%)	0 (0%)	6

Table 5. Direct intervention activities and associated expected intervention behaviors/actions for all studies by intervention type

Intervention	Direct intervention (using chlorine, water collection, flocculation, maintaining filters)	Expected actions/behaviors of HH member as part of research activities	Total
Chlorination	7 (100%)	5 (71%)	7
Filtration	17 (100%)	14 (82%)	17
Flocculation	5 (100%)	4 (80%)	5
Solar disinfection	6 (100%)	6 (100%)	6
Infrastructure	4 (100%)	5 (83%)	6
Disinfection	4 (100%)	3 (60%)	5
Total			**46**

Chapter 5: Discussion

The purpose of this study was to explore the ways in which water interventions and associated research engage women and girls and how these interventions and research studies contribute to or disrupt existing gender norms. We found that the 46 interventions included in our analysis were either gender blind (37%) or gender unequal (63%), according to the WHO GRAS scale. Furthermore, the majority of studies (95%) relied on women and girls to conduct intervention and research activities.

Our study found that 95% of all water interventions rely on women and girls to implement the intervention. These interventions targeted different members of the household to perform the required intervention actions or behaviors. For instance, mothers (44%), caregivers (37%), and women who are non-caregivers and non-mothers (26%) were most frequently targeted by the interventions. Two percent of the interventions targeted the eldest daughter of the household specifically. This analysis demonstrates, that women and girls disproportionately bear the responsibility of intervention work, just as they bear the responsibility of water fetching, and also other domestic work, including cooking, cleaning, and managing the household water supply (Dankelman & Jansen, 2012; Graham et al., 2016; Sorenson et al., 2011). The women and girls in these communities are upholding these traditional gender and cultural norms by playing multiple roles as the essential providers and users of water, while also doing labor around children and their health. Our findings also suggest that public health practitioners leverage these existing social norms for these water interventions, rather than challenge the status quo, making them complicit in upholding these social norms to benefit the intervention outcome. The messaging by public health practitioners reflects that when mothers or female caregivers take care of household water,

record household diarrheal incidences, and complete intervention related education trainings, these actions lead to better child health and development outcomes (Tolani & O'Reilly, 2018). Linking actions such as filtering water with child wellbeing can place the responsibility for family health on mothers (Barnes et al., 2015) and in their role as caregivers, increases the burden to change and maintain behaviors to inhibit the spread of disease (Amaro, Raj, & Reed, 2001). Our review demonstrates that most POU water quality interventions that aimed to decrease diarrhea follow this pattern, whereby mothers and other women are relied on and have the added burden of the intervention implementation. There is a need to look at other intervention types with other target outcomes.

In addition to the activities directly associated with the interventions, such as water treatment and collection, our study found that women were asked to keep diaries, answer surveys and participate in other research activities. None of the studies analyzed acknowledged the time requirement these research activities placed on the women in the households. Notably, this work was unpaid. Studies have argued that gender inequality in unpaid household care work is the missing link that influences gender gaps in labor outcomes (Ferrant, Pesando, & Nowacka, 2014). The interventions and research are therefore engaging in this model of undervaluing women. Water quality interventions can have positive outcomes on health and diarrheal disease, but they do not have to come at the cost of undervaluing women and their time. Integrating benefits to women, including payment or other incentives, should be integrated and enabled by funders.

While the majority of studies targeted adults, a small proportion (6.5%) targeted children, and one study targeted the eldest daughter in the household. By specifically targeting children, these interventions can perpetuate gender stereotypes and dynamics from an early age. Akkan *et al*.,(2019) found that adolescents who care for young children and manage household activities,

constantly negotiate this caretaking time with their personal time for socializing with peers and completing educational tasks (Akkan, 2019). Household size is another important consideration as there is a positive correlation between increasing household size and the amount of household work (chores, cooking, cleaning and child caring) an older girl is expected to complete (Edmonds, 2006). Interventions that are complicit in these gender norms may risk further perpetuating gender inequity from a young age.

The relationship between gender norms and water interventions particularly among children and young girls is an important and growing field. In a different, but related context, water and sanitation interventions at the school level have demonstrated great benefits on school performance, lowered rates of absenteeism, and sufficient hydration (Jasper, Le, Bartram, & health, 2012). Other successful water interventions implemented at the school level have focused on improving sanitation facilities, which allowed girls to practice menstrual hygiene and reduced school absenteeism due to menstrual cycles. Therefore, household water interventions that do not consider gender equality and place additional burden on girls from a young age, are not only reinforcing gender norms of the role of girls at home, but are also potentially counterproductive to other interventions that are trying to advance girls in school. There is an opportunity for household interventions to also promote gender equity especially for young women rather than continuing the dialogue of girls as caretakers of their home and family members.

This study found that none of the water interventions were gender transformative. This work reveals a unique opportunity for public health practitioners to look beyond the scope of their current program goals and to expand the scope of behavior change interventions to address social and structural factors, such as gender norms and inequalities. There is evidence that integrating gender into behavior and social change interventions may be beneficial for effective program

interventions. Evidence from the field of sexual reproductive health with interventions that sought to empower adolescents and their families resulted in changed norms around child marriage in Nepal (Kraft, Wilkins, Morales, Widyono, & Middlestadt, 2014). Interventions that integrated gender in curriculum at medical school in the Netherlands resulted in less gender segregation within specialties and male physicians' desire to participate in care responsibilities (Verdonk, Benschop, De Haes, & Lagro-Janssen, 2009). In the agriculture sector, similar to household water management, women play a significant role in food production, access and utilization. Interventions and programs have paid attention to gender equality related to roles and responsibilities, rights of ownership, women's control over assets (natural resources and information), and decision making power. This in turn, leads to improved health, welfare and stability of households (Akter et al., 2017).

There are several limitations to this study. First, by using the Clasen *et al.*, (2015) review we only included studies published up until November 2014. It is possible that there are newer studies published since 2015 that we did not include in our analysis and which have modified their approaches and may differ in their engagement of women and girls. Our work can be viewed as a methodological test to inform future, more comprehensive research in this area. This study also assumed that when caretakers or caregivers were mentioned in intervention studies, that this referred to a woman. This assumption was based on a consideration of the global context and settings in which the 46 studies took place, and that women in the countries this study assessed typically bear the brunt of domestic work and caretaking. Finally, the studies were categorized according to the WHO Gender Assessment Scale by a single reviewer, which could have introduced reviewer bias.

This is the first study to evaluate interventions to assess how women and girls are engaged. This study lays the foundation for additional studies to implement the WHO Gender Assessment Scale in order to explore the gender dynamics of these interventions, specifically assessing who is targeted by the water interventions and what activities are expected of the key players. There are real risks of reinforcing social and gender inequalities in these communities but this is not an inevitable consequence of water interventions. There are opportunities for change. There is evidence that closing gender gaps accelerates progress towards other development goals. Analysis based on the OECD Social Institutions and Gender Index (SIGI) data finds that lower levels of discrimination against women are linked to better outcomes in several fields such as educational attainment, child health and food security (Branisa, Klasen, & Ziegler, 2013). Water project practitioners should challenge gender norm stereotypes and encourage families as a whole to tackle water access, storage, and supply issues. Women may be targeted for their knowledge, but they should be compensated for that knowledge so their time is valued. Funders should support incentives to properly compensate women and girls. Moving a water intervention along the gender scale continuum from unequal to accommodating to transformative requires a critical examination of gender roles and norms as part of formative research in order to inform intervention design. Changing the social and cultural paradigm in which water and sanitation programs are conducted, to one that engages women and girls equitably, has the potential for significant advances in health and development outcomes.

Chapter 6: Implications and Recommendations

The purpose of this study was to explore the ways in which water interventions and associated research engage women and girls and how these interventions and research studies contribute to or disrupt existing gender norms. Our study found that the POU interventions to decrease diarrhea incidence were classified as gender unequal (63%) and gender-blind (37%), according to the Gender Responsiveness Assessment Scale (GRAS). These results suggest that intervention practitioners appear to uphold the norm of burdening women for the benefit of their intervention goals. Rather than challenging cultural and social norms surrounding women's role and labor in the household, these intervention studies are complicit with the status quo. Research in the water sector suggests that women and girls are disproportionately disadvantaged when it comes to gender-water relationships and bear the burden of ensuring access to safe water (Das, 2017). Understanding women's roles in water collection, storage, and management requires attention to a complex relationship between caretaking of families and domestic uses of water. Around the world, women spend two to ten times more time on unpaid work, which encompasses cooking, cleaning, and caring for children and other family members, than men (Ferrant et al., 2014). Gender patterns in the amount of time devoted to unpaid work cut across geographic regions, household income, and other household variables (Chan, 2018).

A central finding from our study was that women and girls were expected to complete unpaid research and intervention activities in order to achieve successful intervention outcomes. While this unpaid time commitment was not acknowledged by the intervention practitioners, this speaks to a larger challenge in which unpaid work is commonly left out of policy agendas with the misconception that it is difficult to measure and is unrelated to policies. Gender inequality in unpaid household work may represent the missing link that influences gender gaps in labor

outcomes (Ferrant et al., 2014). For instance, time saved from collecting and managing household water can be used by women for economic gain and personal and professional development. It is clear that the interventions extracted time from women and it is possible that time was saved as a result of the interventions, but none measured this and it cannot be assumed.

There is an opportunity for public health practitioners to critically evaluate unpaid labor and time commitments during the design and implementation of interventions with the goal of net positive time savings for women or understanding the time burden and compensating for it appropriately. Future research is needed to better understand household negotiations of labor and time. For example, gaining access to disaggregated data on women's and men's daily activities can help practitioners understand women's and men's schedules and plan for equal participation of both sexes. Once these cultural and social norms surrounding women's multiple roles in the household and community are well characterized, then public health practitioners can investigate improved ways to implement interventions without placing an additional burden on women attributable to the water interventions.

As a first step towards promoting gender equity, awareness on the part of those implementing and researching interventions will be necessary. The Gender Responsive Assessment Scale (GRAS) can serve as a useful tool for intervention studies to consider how they can move across the continuum from gender unequal to gender accommodating and finally to gender transformative. As part of this transition, it is important to critically examine gender roles, norms, and dynamics as part of formative research to inform intervention design or adding elements to the intervention that aim to directly benefit women. This may mean also targeting boys and men as caregivers and including materials that depict men conducting water-related tasks, such as water filtering, storage, and cooking. Incorporating male facilitators and field staff into

interventions will also be important, as these individuals can talk to men and community members about the gender norms that are linked to household and caring roles. As noted in the inclusion criteria of this study, all interventions that we considered had diarrheal incidence as the outcome of interest. As interventions become more gender responsive and even as interventions stand now, key outcomes of interest can include those associated with gender, for instance, time savings among women in the household and educational and economic advancement among women.

Water interventions and development projects have the potential to upend gender norms that promote harmful practices towards women. Notably, our study found that at present, none of the water interventions or research studies are challenging gender norms. As mentioned previously, there is a need to transform the design and implementation of interventions in the context of gender norms. However, there is also a critical need for changes to research as researchers are using women's time, unpaid labor and cognitive labor. There is a need to train researchers and evaluators in gender methodology to design sex and gender analysis into applied research so that gender issues can be rigorously captured and evaluated. It is not sufficient to simply "add" a gender component in the late stages of a given project. Researchers should be reporting on gender, the amount of time they engage people, who and by what sex, for both the research and intervention activities. In the application of water interventions, men in water projects as agents who cook, complete diarrheal diaries, and filter and s water, among other activities, could promote gender-equitable identities, relationships, and practices. To build healthier, equal, and inclusive societies, there is a need to question gender roles, from the researchers all the way down to the manner in which programs are designed, in order to advance gender equality.

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