World Development 188 (2025) 106902

Contents lists available at ScienceDirect

World Development

journal homepage: www.elsevier.com/locate/worlddev

Regular Research Article

Exploring the determinants of household water treatment in Kabul: A COM-B model perspective in a low-income context

Mohammad Daud Hamidi [a,*], Marco J. Haenssgen [b], H.Chris Greenwell [a]

[a] Department of Earth Sciences, Durham University, Durham, United Kingdom
[b] Department of Social Science and Development, Chiang Mai University, Chiang Mai, Thailand

ARTICLE INFO

Keywords:
Water treatment
Household
Behaviour
Kabul
Qualitative research
WASH

ABSTRACT

Access to clean drinking water remains a major challenge in low- and middle-income countries, causing premature death from waterborne diseases, especially in water-insecure settings such as Afghanistan. While technologies and solutions for household-level water treatment exist, models to guide behaviour change for their adoption tend to stress psychological dimensions of behaviour with relatively little grounding in local expressions and contextual drivers of households' water treatment behaviour in low- and middle-income countries.

Speaking to this challenge, our study explores factors influencing household water treatment in *peri*-urban Kabul, using the COM-B model (Capability, Opportunity, Motivation – Behaviour) as a guiding framework for analysis. We conducted semi-structured interviews with a purposive (maximally diverse) sample of 68 participants across two Kabul neighbourhoods to inform the framework. The data was collected from May to July 2021.

Our qualitative findings cover themes including water realities, common water storage and treatment practices, the process of navigating and negotiating water treatment, and discontinuities therein. Among others, this shows that residents' everyday experiences with water are shaped by sensory quality indicators like smell and turbidity, but also illness experiences due to limited formal water information. The complex assemblage of factors shaping households' navigation and negotiation of water treatment options included gender roles, household economics, technology availability, efficacy perceptions, and competing priorities. In addition, our qualitative data documents how the emergency-focused approach to water security by NGOs contributed occasionally to scepticism, trust erosion, and discontinuities in household water treatment methods.

Our study challenges the literature's emphasis on psychological dimensions of water behaviour as similarly salient contextual factors include social dynamics, infrastructure, electricity disruptions, and the physical environment. We recommend that behaviourally-informed interventions should be tailored to the realities of underserved communities, for example by increasing community involvement, targeting affordable technologies resilient to disruptions, and addressing contextual barriers like infrastructure limitations.

1. Introduction

At least 2 billion people worldwide consume microbially contaminated drinking water. Faecal contamination poses a considerable risk of transmitting diarrhoeal diseases and is the greatest cause of mortality in children under the age of 5 years old, accounting for more than 500,000 deaths in 2019 globally (GBD, 2019; WHO, 2022). Populations residing in low-income countries are frequently at risk of contracting diarrhoeal diseases due to the widespread lack of access to clean water and sanitation (Blakely et al., 2005; Clasen et al., 2006). Household water treatment serves as an intermediate remedy in the absence of suitable treatment infrastructure (Clasen et al., 2007; Sobsey et al., 2008).

Common household water treatment techniques around the globe include straining water through a piece of cloth, boiling, solar disinfection, ceramic filtration, bio-sand filtration, using high-tech (advanced) water purifiers, and chlorination in liquid form, tablets or coagulation-flocculation-disinfection available in sachets (Clasen, 2005; Lantagne and Clasen, 2012). However, research has highlighted that simply providing household water treatment interventions is frequently insufficient and the "hardware" must be accompanied by a comprehensive behavioural change model to foster acceptance and consistent and long-term usage (Lilje and Mosler, 2017; Sonego et al., 2013). Yet,

* Corresponding author.
E-mail address: mohammad.d.hamidi@durham.ac.uk (M.D. Hamidi).

https://doi.org/10.1016/j.worlddev.2024.106902
Accepted 11 December 2024
Available online 21 December 2024
0305-750X/

the specification of these behavioural models is neither obvious nor universal and understanding the factors that determine current or desired alternative behaviour is thus a key requirement for behaviour change.

Speaking to this knowledge gap, our study aims to analyse the factors that influence the adoption of household water treatment in Kabul, Afghanistan, as a priority setting of water scarcity (Hamidi et al., 2023a) and poor water quality (Hamidi et al., 2023c). Our primary objective is to contribute to the ongoing controversy in the literature on whether and how contextual factors influence water treatment behaviour. In contrast to previous studies that delivered quantitative and qualitative analyses of the factors determining household water treatment through the lens of RANAS and existing WASH models (Bitew et al., 2020; Callejas Moncaleano et al., 2021; Daniel et al., 2021, 2020, 2019; Mosler et al., 2011, 2010; Tamene, 2021), this paper is based on the most inclusive definition of behaviour, utilizing the COM-B (Capability, Opportunity, Motivation – Behaviour) model (Michie et al., 2011). The study has been designed to capture the local realities of a low-income setting through qualitative research involving 68 semi-structured interviews in two neighbourhoods of Kabul. A secondary objective of this grounded approach is to revisit the psychological factors perspectives in water behaviour that continue to dominate the research literature.

2. Literature review: models of water treatment behaviour

Several theoretical frameworks with different degrees of specificity have been established to help identify the factors determining water and sanitation (WASH) related behaviour and attain better uptake of WASH interventions. Recent systematic reviews would formulate for instance the broad and open-ended Integrated Behavioural Model for Water, Sanitation, and Hygiene (IBM-WASH) by considering psychosocial, contextual, and technological dimensions of WASH-related behaviour at different levels spanning the societal/structural, community, household, individual, and habitual (Dreibelbis et al., 2013; Martin et al., 2018). While this range of factors appears plausible, their concrete expression remains relatively vague and their actual extent is disputed. Some authors would for example maintain that socio-psychological factors are the main determinants of safe water drinking behaviour, whereas contextual factors had little contribution (Lilje and Mosler, 2018, 2017). This argument underlies one of the currently leading approaches to WASH-related behaviour change, namely the RANAS model. This model describes Risk, Attitude, Norm, Ability, and Self-regulation as the main behavioural drivers of WASH and environmental health practices in low- and middle-income countries (Mosler, 2012).

From a more general behavioural science perspective, the emphasis on psychological factors with relatively little appreciation of context-specific socio-economic and cultural drivers of behaviour in the dominant RANAS model may surprise. Daniel et al. (2021) examined the effects of contextual factors on RANAS domains and, eventually, on HWT using Bayesian Belief Networks (BBN). Additionally, a framework was developed that included contextual factors for studying water use efficiency through the lens of RANAS, as described by Callejas Moncaleano et al. (2021). On the other hand, a landmark systematic review by Michie et al. (2011) considered contextual and social elements as integral to any behaviour. Based on 19 behaviour change frameworks, the authors thus proposed the "behaviour change wheel" for designing behaviour change interventions (Michie et al., 2011), whereby interventions respond to enablers and barriers to a behaviour such as water treatment across three main dimensions: Capability (physical and psychological), Opportunity (physical and social), and Motivation (reflective and automatic) – which together form the COM-B model. While capability domains address individual variation in cognitive and physical functioning (e.g., in the form of disability), especially the opportunity domains address issues relating to the context in which behaviour takes place (e.g., the presence of water sources, violent conflict, or gender discrimination).

Compared to approaches dominated by notions of reflective decision-making (which e.g., emphasise information provision to change behaviour), the domains of the COM-B framework appreciate for instance that people make impulsive or habitual decisions without necessarily being aware of the decision-making process, or that not only social norms but indeed the configuration of physical and social spaces can shape whether decisions can be taken in the first place (Webb and Sheeran, 2006). Although the behaviour change wheel does not prescribe specific factors that influence behaviour, it offers an exhaustive range of conceptual domains for bottom-up exploratory analysis, and its widespread application across the globe has helped it build a knowledge basis of contextually sensitive behavioural drivers (and the ensuing interventions to change behaviour) in domains as diverse as public health, personal finance, or energy consumption (French et al., 2012; Michie et al., 2014; Steinmo et al., 2016).

However, although the broader field of WASH has received ample attention through studies on sanitation and hygiene practices (e.g., hand washing or latrine use), relatively little knowledge exists on the COM-B enablers and barriers of household water treatment in low- and middle-income countries. Among the very few instances, Okello et al. (2019) applied the COM-B model to assess a school-based WASH programme conducted in Tanzanian primary schools. Children's motivation to wash their hands improved as they were more aware of the consequences of not doing so. McGuinness et al. (2020) utilized COM-B to determine enabling factors and barriers that influence WASH behaviours. Arriola et al. (2020), in Kenya, deployed the COM-B model to develop a behaviour change intervention for pregnant women and parents of children below two years old that aimed to reduce stunting and promote the adoption of nutrition-and WASH-related behaviours. Charnley (2021) used COM-B to explore the potential for school-based WASH programmes to spur progress toward Sustainable Development Goal 6 (Clean Water and Sanitation) in India, and suggested that opportunity and motivation domains were key determinants of the behaviour. Two studies in western Kenya by Ellis et al. (2020) and Ewart McClintic et al. (2022) also aimed at identifying factors affecting the adoption of nutrition and WASH behaviours by deploying the COM-B model, suggesting that the most significant barriers to practice were severe lack of social and physical opportunities. Studies such as these illustrate that the COM-B model can usefully be applied to water-related behaviours, and that it has the potential to inform the relative balance of contextual and individual factors of behavioural change.

3. Methods

In settings where there is a dispute about the nature and expression of the various factors influencing water treatment behaviour, explanatory quantitative methods are inferior to the context-sensitive and bottom-up perspective that exploratory qualitative methods afford (Creswell and David, 2018; Haenssgen, 2019). We therefore present in this paper the results of cross-sectional qualitative research that form the first stage of a sequential (exploratory) mixed-method research design and lays the groundwork for subsequent survey research that builds on the qualitative insights (Creswell and David, 2018). The operationalisation of qualitative findings in the subsequent quantitative stage is detailed in Hamidi et al. (2023b).

The data collection instrument was a semi-structured interview guide that included two main parts. Part 1 included open-ended questions on 1) Main water source, storage and knowledge of water quality, 2) Knowledge of health risks from poor water quality, and 3) Water treatment and knowledge of techniques in the household; and Part 2 captured demographic and household characteristics of the participants (for the interview guide, see supplementary material 1). The main topics of the interview guide were informed by the existing literature on access to water, household water purification practices, and existing behaviour change frameworks, including Addo, Thoms, and Parsons (2018); Lilje and Mosler (2018); Michie, Atkins, and West (2014); Mubarak et al.

(2016); Ochoo, Valcour, and Sarkar (2017); Sigel (2009); Slekiene and Mosler (2019); UNICEF/WHO (2006); and Wutich (2006). The flexible and open-ended format of the semi-structured interview approach enabled residents to share their water realities from their perspective and highlight the drivers of purification practices on their terms without the research team pre-imposing or favouring specific types of factors.

To explore the diversity of residents' living environments and water treatment behaviours, participants from the two *peri*-urban communities of Bagrami and Doghabad in Kabul city (see Section 4 for a description of the study context) were selected purposefully based on their residence region, age, gender, economic status, and variability in access to water resources. Concurrent analysis and residents' guidance supported the sampling process, which continued until all selection criteria were successfully incorporated into this study. Following emerging practices in development research for low- and middle-income countries, we employed high-resolution satellite imagery to support the spatial distribution of the sampled households (Cajka et al., 2018; Grais et al., 2007; Haenssgen, 2015). The imagery, with a resolution of 50 cm, was provided by the National Statistic and Information Authority Afghanistan from Planet Labs, Skysat Images (2020).

The resulting data involved audio-recorded interview records with an average duration of 30 to 40 min. The questions were posed either in Dari or Pashto, depending on the native language and/or the preference of the interviewee (following WHO (2010), the interview guides were translated and back-translated). Among the 68 participants, 36 were from Doghabad: 13 males and 23 females, with an age range of 21–65 years (mean: 37 years). The remaining 32 participants were from Bagrami: 3 males and 29 females, aged between 18–60 years (mean: 34 years).

Refusals to the invitation to partake in the study were limited and primarily due to feeling nervous or participants having concerns about audio-recording their responses (in these cases, the candidates were replaced with persons with equivalent characteristics). Male participants were mainly interviewed by a male researcher, whereas female participants were interviewed by two female research assistants. All participants were provided with a Participant Information Sheet before obtaining recorded verbal consent, which the researchers read out to the participants due to the low level of literacy in both study areas. The data collection took place from May to July 2021, shortly before the Taliban seized power in August 2021.

The audio-recorded semi-structured interviews were transcribed verbatim and translated into English. We conducted preliminary data analyses concurrently and during the transcription and translation, which helped inform the development of the analytical framework as well as the sampling process. The formal stage of the qualitative analysis proceeded upon completion of the transcription using NVivo 12 (QSR International, 2018). This stage involved thematic analysis and was conducted by the lead researcher (MDH) in the original interview language to preserve the original context and maximise the informational content of the interviews for the analysis (Haenssgen, 2019). We received ethical approval from the Department of Anthropology at Durham University (Reference: ANTH-2020-11-28T00_10_33-lgww95), and we further informed Kabul Police headquarters, the head of the city district/village, the Imam of the mosque in the area, and the local division of Kabul police about our research activities (see supplementary material 2).

4. Results

4.1. Context

Our study is situated in Afghanistan, where 4108 deaths of children under five were attributed to diarrheal diseases in 2019 (GBD, 2019), illustrating the enduring impact of waterborne pathogens on child mortality. We selected two study sites in the city of Kabul with high rates of water-borne diseases, namely Doghabad (located in District 7 of Kabul city) and Bagrami (divided between the existing 12th district, and the planned 22nd district of Kabul city) – shown in Fig. 1. Doghabad region with a population of 50,000 people is an unplanned *peri*-urban area characterized to have highly microbially contaminated water. Bagrami has a population of 100,000 people, a planned *peri*-urban area and the water in the area is saline (CIESIN, 2018; Hamidi et al., 2023c; NISA, 2020). Water-borne diseases reported by the Kabul Managed Aquifer Recharge Project (KMARP, 2018) in Doghabad included amoebic dysentery and salmonellosis. In Bagrami the range of prevalent waterborne diseases is broader, including amoebic dysentery, hepatitis A, typhoid & paratyphoid, shigellosis, and salmonellosis.

The two sites are located in two different watersheds, one having more constraints than the other in freshwater availability due to the impact of droughts and low river recharge rates. For instance, the shallow groundwater depth in Doghabad is 25–30 m below ground level (mbgl) while it is 3–7 mbgl in Bagrami. Most households in Kabul relied on groundwater as the primary drinking water source, including in the areas studied here. Besides wells and hand pumps, people depended on bottled water, water trucking, and private water networks.

The most common methods of water treatment (based on the qualitative research) are presented in Table 1, whereby water boiling was the most commonly mentioned treatment, but not consistently or universally adopted.

Plastic gallon containers and tankers (i.e., larger storage barrels), and steel tanks were among the most common means of storing drinking water within households. However, marked disparities in water storage emerged between middle-income and lower-income households. For instance, middle-income families stored tanks indoors or covered to avoid sunlight, keeping water fresh throughout a year. Lower-income families lacking sheltered storage exposed tanks to direct sunlight on rooftops, resulting in algal growth.

4.2. Behavioural dynamics

Our qualitative analysis revealed a complex landscape of how residents assessed and navigated water contamination risks, making decisions on water treatment, like boiling and chlorination, but also active considerations of when and when not to apply them.

4.2.1. Weighing water risks and benefits

Interviewees commonly expressed a general inclination toward water treatment and deemed it a useful solution, indicating widespread understanding of its benefits. However, local notions of water safety and treatment effectiveness were varied. For example, informants highlighted that boiling water was not wholly effective at killing bacteria or purifying water generally, but for practical reasons, they would still boil groundwater to achieve at least *some* protection rather than none. A 28-year-old affluent Doghabad resident, observing the digital water quality indicator of his advanced purifier for boiled and raw water, concluded concisely: "*Boiling water is not as effective as it is said to be, but it is better than raw water*" (R4, the recording number and corresponding interviewee details are presented in Table S1).

Aside from individual health risk assessments, practical constraints also shaped households' water treatment practices. In Kabul, the incidence of waterborne diseases peaks in the summer, which would warrant widespread water boiling. However, low-income families without fridge access could not boil water in summer, as it took too long to cool for consumption – "*our children do not drink boiled water*" (R17). The physical environment created constraints preventing households from water treatment, contributing to waterborne diseases despite explicit understanding of health risks. Seasonality and environmental effects further influenced water quantity and quality. These intermittent conditions in people's "physical opportunity" required a routine re-evaluation of treatment options. Community members recalled that during occasional Kabul droughts, they fetched only turbid groundwater from handpumps for domestic use, often providing the initial motivation

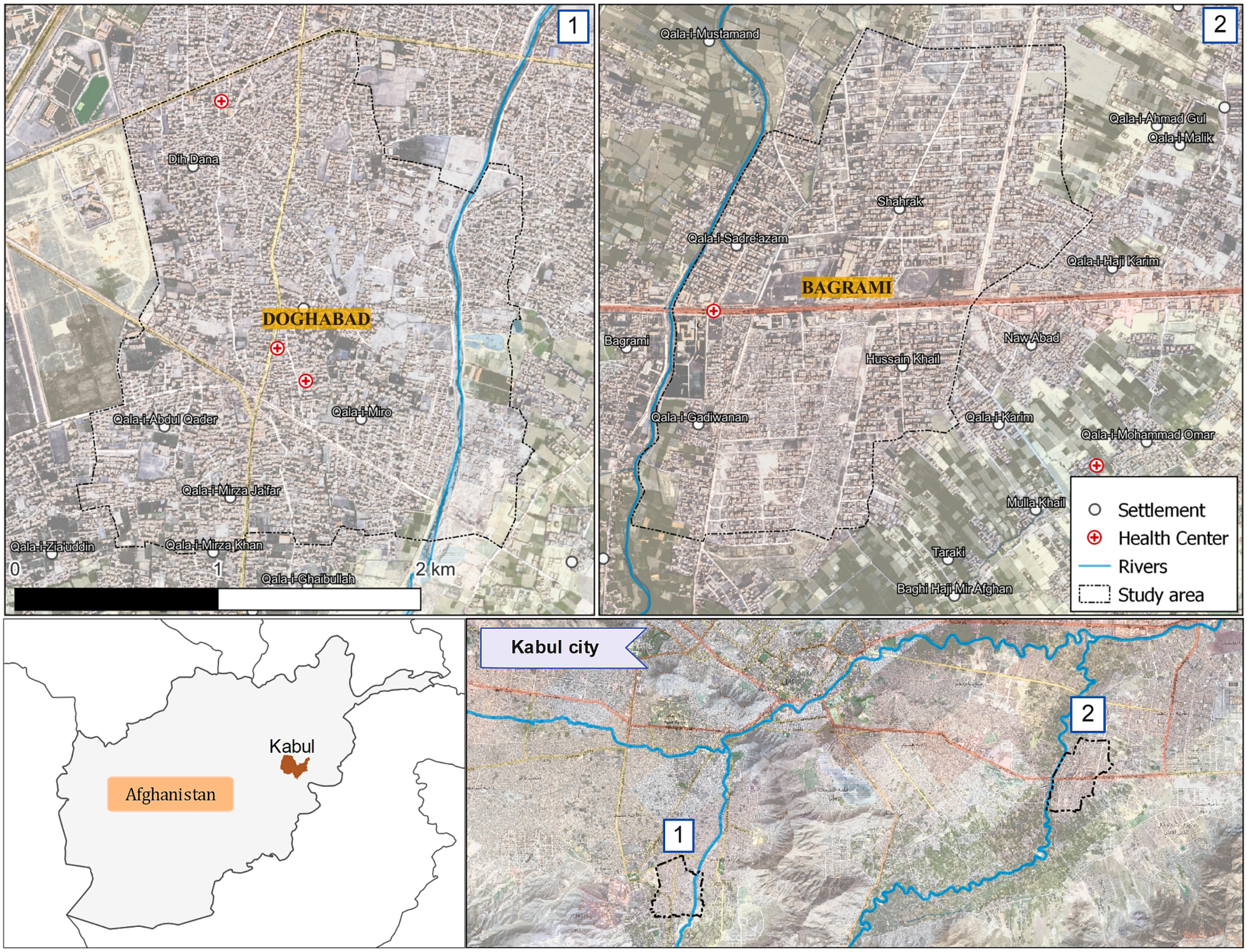

Fig. 1. Detailed map of Doghabad (1) and Bagrami (2) with settlements, health centers, and rivers. Inset: Location of Kabul within Afghanistan.

to start boiling drinking water.

Where circumstances prompted water treatment, residents' reflective assessments of options involving cost and efficacy considerations influenced ensuing uptake patterns. These considerations were partly informed by past experiences and experimentation with different techniques. For example, those boiling drinking water were more vocal in articulating the (at least theoretical) benefits. Such observations were common, informing community members' understanding and decision-making about purification methods.

Temporary water boiling uptake occurred for acutely ill children (i.e., a respite from health risks for specific members), and during droughts (i.e., responding to visible turbidity markers). More concerning was gradual health risk perception adjustment over time, often sparking treatment cessation. A 40-year-old tailor from Doghabad exemplified this with chlorine (R5). The discussion surrounding water treatment was reignited only after some time, triggering a recall: "*We used chlorine in the past, but* [it's] *now forgotten, erased from our memories. I've just remembered it.*" Probing why they discontinued it, he explained: "*We are a bit reckless people* [in general]. [We] *Did not take it seriously and did not use it.*" Though women held treatment responsibility, his recklessness comment suggested that a gradual acceptance of water-borne disease risks led him to stop chlorination. This "reckless" notion was common in treatment discontinuation narratives, recognizing persistent risks (e.g., "*I haven't boiled water since she* [the respondent's daughter] *got better* [recovered from the disease]. *I only boil water when she is ill. I got a bit reckless.*").

The results presented here demonstrate human behaviour's dynamic nature. The practical consequence is that behaviour change is unlikely to persist long-term. Even if contexts continue accommodating behaviour, growing risk tolerance is still prone to undermining treatment over time, all else equal.

4.2.2. Competing priorities

The informants revealed that adopting water treatment involves more than weighing the costs and benefits of clean water. These behaviours also compete with other household priorities and behaviours, influenced in part by economic status, household size, and willingness to pay. Competing behaviours included purchasing already treated water from trucks and subscribing to a private water supply network.

Respondents routinely emphasized how household economics influence water treatment, as tight budgets force difficult trade-offs on spending scarce time and money. Should limited resources go towards producing clean water, buying necessities like food and medicine, or raising children and maintaining the household? A 35-year-old woman in Bagrami explained that, despite experiencing waterborne illness and doctors advising boiling water, her household simply could not afford the time and fuel costs to do so (see Quote 27 or Q27; quotations from the interviews are presented in Table S2).

Further, chlorine was distributed to internally displaced people, mostly displaced to Kabul from conflict-affected areas. Some lived in tents provided by international NGOs as temporary shelters. Regardless, these community members disliked the taste of chlorine and/or did not

Table 1
Common forms of household water treatment techniques in the study sites.

Household water treatment technique	Applicability	Energy source requirements	Cost
Straining through cloth †	Turbidity, sand particles, and micro-organisms	None	No cost
Boiling	Bacteria, viruses, and protozoa in water	Electricity, Gas, Wood	Depending on the source of energy and frequency of performing.
Liquid Chlorine (250 ml) ††	Bacteria and viruses in water, low protection against protozoa	None	60 Afghani/bottle (0.75 USD)
Solar disinfection	Viruses, bacteria, and protozoa in water	None	No cost if using recycled plastic bottles
Sachets or Tablets ††	Bacteria, viruses, and protozoa in water	None	30 Afghani/sachet/ packet (0.38 USD)
Sand filtration †††	Protozoa and most bacteria, not as effective against viruses	None	High initial cost
Advanced water purifiers	Bacteria, viruses, and protozoa in water	Electricity	Above 8000 Afghani (100 USD)

Source: Research fieldwork; "applicability" based on (CDC, 2022).
† Depends on the type of cloth and directly depends on micro-organism size.
†† Distributed by NGOs, and available in pharmacies.
††† Promoted by NGOs only through certain projects.

perceive its health benefits. Due to low income after displacement, there were clear signs they sold the chlorine in markets or to other villagers for cash, arguably small payoffs, but allowing the purchase of other necessities (see Q28 and Q31).

Where choices were possible, interviewees expressed willingness to pay. Despite economic challenges, most conveyed a high desire for quality drinking water – similar to findings by McPhail (1993). For instance, a 63-year-old male participant explained households were willing to pay for cost-effective purification if affordable, has long-term benefits, and doesn't add to daily expenditures like other methods (Q29).

Groundwater overexploitation is a major challenge in Kabul, exacerbated by recurrent droughts markedly depleting aquifers in Doghabad and central Kabul. This water scarcity prompts behavioural changes, especially among affluent central households. Participants raised concerns about water rejection from high-tech filters – reverse osmosis systems reject ~ 3L per 1L purified (Bestrowaterpurifier.in, 2017). Acutely aware of wastage amid scarcity, a 22-year-old student described recycling rejected water: "*The problem is that it wastes water, so we try to use the wastewater from the filter for washing dishes*" (R15). Overall, high-tech purifiers would increase water abstraction for treatment (draining groundwater), and further constrain access for poorer households solely reliant on dwindling groundwater.

4.2.3. Discontinuities

Our findings, thus far, underscored that the reflective uptake of water treatment did not ensure continued use. Participants revealed increasing health risk tolerance or changing circumstances leading to a re-evaluation of benefits/risks, gradually discontinuing treatment. In this section, we presented how intermittent use and emergency interventions by NGOs played a role in discontinuing household water treatment.

Early in the Kabul water contamination crisis, families used to pour chlorine in wells intermittently every 1–2 months. As a result, many households did not observe the promised health benefits of chlorine purification and gradually ceased using it (Q26). Community members perceived it as ineffective since it did not visibly improve water quality based on sensory judgments (colour and tea scum), and led them to abandon well water for drinking. Similarly, a 45-year-old Bagrami homemaker described experimenting with chlorination but found that it did not meet her household's needs, explaining: "*We used chlorine in the well several times, but it did not change* [the water quality]" (R41), thus discontinuing use due to lack of effect. Similarly, those households triggered to use boiled water due to droughts, highlighted that the practice did not necessarily persist. For instance, a 50-year-old man argued: "*At that time* [of the drought]*, we boiled water for six months*" (R1). However, the household reverted to accustomed untreated water use once the drought passed after those six months.

In interviews, community members typically appreciated NGOs' efforts to improve the water landscape but also criticized their approach of delivering interventions reactively as emergency responses. NGOs' efforts were perceived as ineffective in preventing problems, only responding to specific situations. In particular, for at least the last three decades, water contamination in Kabul has been a major issue, yet many programs were frequently implemented to respond to acute watery diarrhoea (AWD) outbreaks without evolving to address longer-term root causes of local water contamination. Instead, efforts continually took the form of emergency, short-term initiatives. Interventions in *peri*-urban and rural Kabul often focused on low-income or displaced households, providing free chlorine for water treatment. The emergency response approach of local donors and NGOs in Afghanistan was common knowledge: at the start of each year, the WASH cluster of NGOs and donors led by UNICEF would prepare a budget for emergency response materials (i.e., stockpiling) and activities. The result was a one-size-fits-all emergency solution for anticipated problems that year. A 48-year-old female informant from Doghabad described experiencing the practical manifestation of this situation:

> *Some young people from NGOs visited our streets, and my father-in-law told them about the problem* [taste and colour of water]. *They said they would add chlorine to the well – chlorine tablets. They did, and it smelled* [of chlorine] *for one week, but it didn't help change the taste of water. It's been about a year since we stopped trying, thinking it wouldn't get better. Now, we buy water for drinking.* (R29)

The short-term, emergency-focused approach of water purification programs delivered by NGOs and the government thus failed to address local causes of contamination as well as the everyday water realities experienced by the target population. The continued problem unintentionally provoked discontinuation and likely eroded trust in household water treatment viability, specifically chlorination and Aqua tabs. From a process perspective, these problems indicate that community members were rarely consulted in program design stages (particularly emergency response). Only village leaders and imams were occasionally involved in delivering programs like household water purification campaigns, but their participation also risked undermining trust in uptake since they were usually paid to promote programs and enable successful intervention delivery. Nevertheless, households participated in interventions not because they observed tangible benefits, but because they were persuaded or coerced into nominal compliance. While not necessarily due to malevolent intent, this coercion could stem from well-meaning persuasive efforts that left communities unconvinced, financial incentives for struggling households to participate, and/or a sense of social obligation towards local leaders whom community members respected and wished to maintain goodwill.

4.3. Factors influencing household water treatment

4.3.1. Conscious and sub-conscious reasoning (motivation)

In *peri*-urban settings in Kabul, our study –framed by the COM-B model– uncovers multi-faceted factors influencing household water treatment. A key theme shaping daily water realities was quality assessment by the community members, which typically relied on sensory attributes such as taste, colour, turbidity, and scum formation in tea – the expressions of which suggested extensive sources of water contamination.

Among the sensory markers, representations of "good" and "bad" water quality based on taste were vividly evident in the responses and narratives of the residents, typically expressed in relative terms but with varying reference points. For instance, respondents made comparisons of the taste of water from the same well over time (Q5), compared water taste across different areas that they visit or where they originate from (Q6), or contrasted different water sources such as well water vs. bottled water or trucking water (Q7). The importance of taste as a quality indicator was evident to the participants as well (see the exchange with a 36-year-old female homemaker in Q8). Water colour was a similarly important quality indicator for the research participants. According to residents in both communities, colour indicated that the water was stagnant, or contaminated from neighbourhood activities like wastewater disposal (Q9). The third key marker was turbidity (a sensory assessment through visual inspection). Turbidity experiences differed based on the primary water source. For example, individuals utilizing water from private network sources reported low turbidity levels (Q10), whereas high turbidity was reported from public hand pumps and water wells, especially during dry years (see Q11 and Q12). The fourth common marker of water quality was the pervasive "*oily layer*" phenomenon, which is almost universal in the Kabul city area. From the perspective of community members, after boiling water "*a layer is formed*" (R19) that is visible in the glass of tea, therefore also shaping the experience of its consumption (and potentially creating powerful and negative affective associations that relate to automatic motivation in the COM-B framework).

Sensory factors like taste, colour, turbidity, and tea scum informed community members' assessments and choices about drinking water.

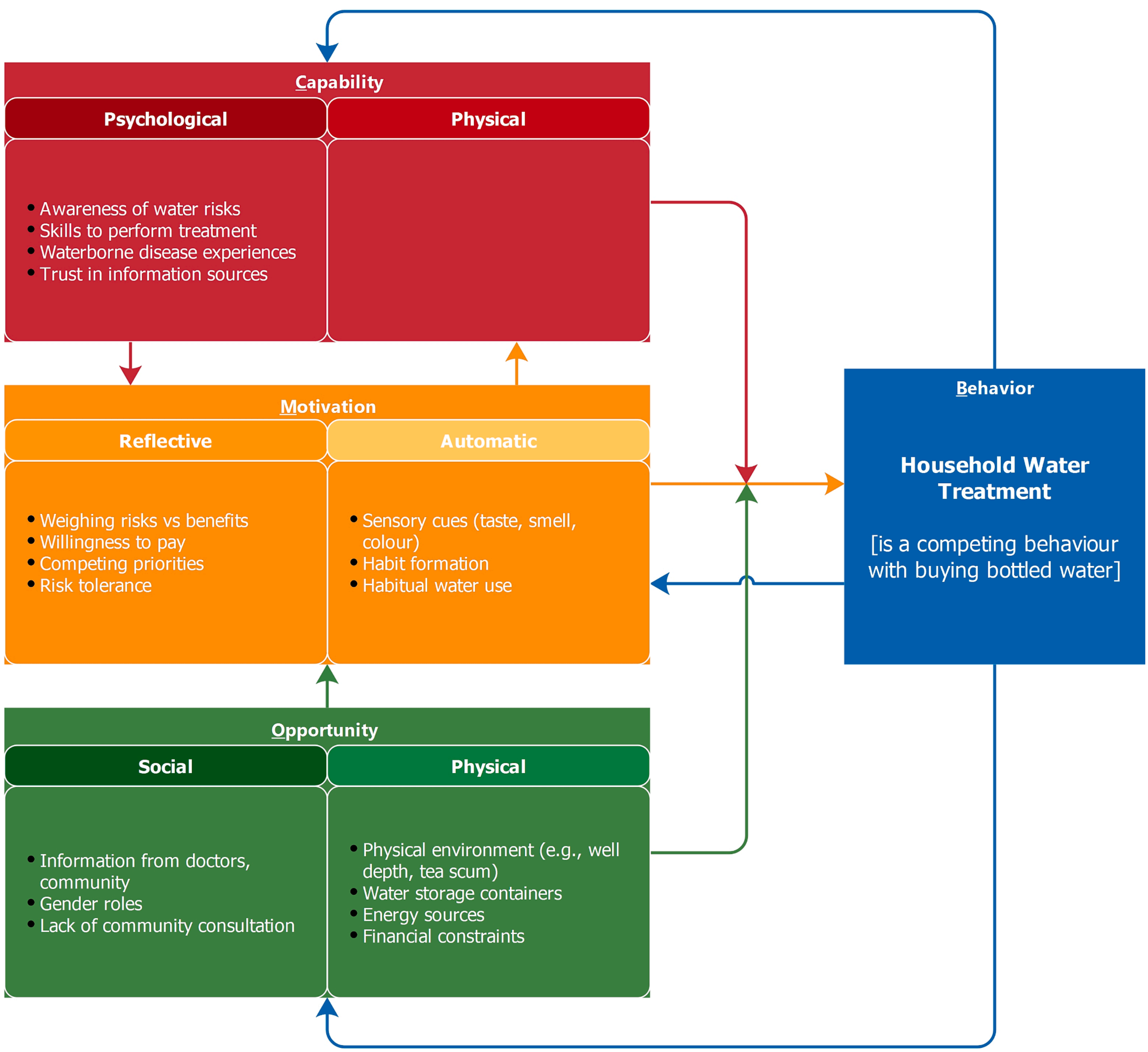

Fig. 2. COM-B factors, at the source level. Note: The direction of arrows indicates the unidirectional influence of a domain on another, and the bullet points indicate the factors that arose from qualitative analysis.
Source: Authors, adapted from West and Michie (2020)

Those with access to private supply networks or trucked water often chose these options for their better taste and colour. This issue bears significant weight; local residents relied on their individual, sensory evaluations of water quality, as such information was absent from water distributors–whether governmental, private water supply entities, or other water providers such as bottled water suppliers and water trucks.

Our field research indicated a lack of official government policies for consistent assessment and reporting of water quality from local water vendors, including private suppliers, bottled water companies, and water trucks. While occasional visits by ministry officials did occur, their limited impact stemmed from security constraints (impeding physical access) and widespread corruption hindering effective issue resolution arising from these intermittent checks. The upshot is a persistent lack of information for water users. A 25-year-old female informant described that even in the case of trucking water, lack of dependable information meant that community members needed to consistently rely on assumptions and heuristic markers of water quality (Q13).

Interviewees often linked the practice to past experiences of water-related health risks or in response to acute illnesses within the household, particularly those afflicting children. For instance, a mother who had been boiling the water purchased from water trucks for her child suffering from a water-borne disease ceased this practice once the child had recovered (Q19). The primary source of water therefore did not influence the decision to boil water when a family member was ill, which underscored the behavioural influence of cognitive factors such as awareness and fear of risks associated with untreated water. Community members were particularly attentive to children's health "*because they fall ill quickly*" (R28).

Other intermittent factors such as weighing risks and benefits, willingness to pay, and competing priorities were related to automatic and reflective motivation that indirectly influenced household water treatment practices through physical opportunity – see Fig. 2.

4.3.2. Individual variation (capability)

Among the study participants, encounters with waterborne diseases were prevalent, serving as an important facet of local water realities that influenced household water treatment behaviours. For example, infections caused by *Helicobacter pylori* were almost universally known within the community and colloquially referred to as "*H. Pillory.*" Due to *H. pylori*-induced chronic and persistent diarrhoea, community members frequently sought medical treatment. This not only exposed them to expert guidance regarding water quality but also catalysed a re-evaluation of their attitudes and practices around clean water. For instance, a 57-year-old female household member from Bagrami explained how they "*didn't have a filter and used the raw water for five or six months. After falling sick* [and being] *diagnosed with H. Pylori, we then bought a water filter*" but also described water quality not merely through sensory attributes but even with reference to microbial contamination: "*When the water is filtered* [boiled]*, it will not have microbes. Raw water has microbes*" (R65). In contrast, milder episodes of diarrhoea typically remained unreported to medical authorities, both for adults and children. While individuals commonly employed herbs and "*anise seeds*" as home remedies (R53), they might not be exposed to medical information but nonetheless still boiled water in response to the illness of their household members.

Research participants reported various health conditions, such as stomach aches, vomiting, nausea, and typhoid, both personally and within their households. These conditions were commonly attributed to water-borne diseases. A notable account came from a 50-year-old female homemaker whose family member contracted typhoid (Q16). Her narrative underscored several elements that consistently appeared in our qualitative research: community members typically possessed an understanding of water-borne illnesses; they directly associated water purification with contamination mitigation; they recognized the health and financial implications of infections from contaminated water; and they actively identified and negotiated solutions for water treatment.

On the other hand, in lieu of dependable information, communities often trust local water suppliers. In Bagrami, where water contamination led many to rely on trucking water, trust-based relationships developed between the community and vendors: consumers depend on vendors' claims about water quality, even if it's as simple as "*the seller said that it is clean*" (R50). Technical solutions had limited success in addressing the information deficit. Rarely did community members possess devices to measure household water quality. Only wealthier households accessed indicators via advanced purifiers, yet interpreting the metrics remained challenging. For example, a water purifier user tracked fluctuations in the digital indicator but understood them only relative to the "good water quality" threshold from the sales brochure: "*Above 100 is not drinkable and below 100 is allowed* [to drink]" (R10). The mere provision of technical information may therefore not automatically resolve uncertainties surrounding the quality of water.

Other factors worth mentioning that indirectly influenced capability through motivation and opportunity included having skills to perform household water treatment – particularly related to psychological capability – as shown in Fig. 2.

4.3.3. External physical and social influences (opportunity)

A key theme in shaping Kabul households' water realities was the prevailing information environment, which can influence the way households navigate and perform water treatment. Key elements of this landscape were community members, "*doctors*" (broadly defined as medically informed people), mass media, religious and community leaders, non-governmental organizations, and commercial operators (see Table S3). A salient theme of how COM-B dimensions played out in this landscape was the domain of social opportunity: Making sense of water through the information exchange among community members or through media would enable household water treatment and indirectly also influence reflective motivation, psychological capability, and reflective motivation in this process.

Most participants identified "*doctors*" as their main source of information on water quality and water purification. The local doctors were very likely to encourage people to reconsider their drinking water sources and to consume treated water, either by boiling it, buying bottled water, or buying from water trucks, particularly for ailing children (Q1). Nevertheless, interactions with doctors were limited as medical costs were unaffordable for lower-income families. Thus, people receiving health information from doctors tended to be more affluent residents who had experienced severe water-borne diseases. Alongside professional advice, social interaction among people was another important element of the local information landscape. Its impact on behaviour was noticeable as community members in Kabul described following others in performing behaviours that they talked about or demonstrated (Q2).

With the declining trend of water quality in Kabul, community members frequently conversed about water quality and purification techniques. Conversations between household members and relatives were relatively more influential than those in the broader community in shaping practices, even without direct demonstration (Q3). At the same time, social interaction could also discourage or confuse water purification at the household level. For instance, a 19-year-old female student from the Bagrami area described how her brother had just "*installed a water purifier* [at his home]*, and so he said that we should install one as well.*" However, after the family bought a water filter, it was left idle as the "*brother said it doesn't work properly, so we didn't install it.*" (R56). In other situations, word-of-mouth and fluid concepts could cause confusion about water treatment and quality, for example, as respondents routinely conflated the notions of "*boiled*" and "*mineral*" water (Q4).

Despite its ambiguities, the fragmented information landscape in Kabul inadvertently left some residents without potentially life-saving information. For example, emergency aid interventions and their information often targeted limited areas, while media campaigns routinely missed households without stable electricity or TV sets and radios.

Additionally, due to social norms, men usually controlled the viewing choices on TV and women, burdened with household duties and childcare, tended to miss peak-hour advertisements. It was therefore not unusual to encounter female respondents such as a 45-year-old homemaker in Bagrami who had never come in contact with any of the wide range of water purification methods from boiling, straining via cloth filtration, chlorine, solar disinfection, to advanced water filters (R58). Despite their central roles in local communities, the Imam (local mosque head) and Wakil (community representative) appeared uninvolved in disseminating water quality information. While both are respected and recognized by authorities to address community issues, and the Imam has a religious duty to address community challenges, no instances were reported where either of them discussed water quality or purification.

The qualitative analysis highlighted the cost of purifiers as a further complicating factors of household water treatment in Kabul. A high-tech purifier costing $150 was deemed "*expensive*" (R67) and widely unaffordable. Participants consistently cited household economics as the primary reason for ongoing consumption of bad-tasting, poor-quality water:

> *We bring water from this house* [pointing to a house], *and their water is a little better – it is not drinkable either, but we have to* [drink it]. (R40)

In practical terms, our interviews and observations revealed that mothers predominantly dedicated their time to childcare and were responsible for household water treatment, primarily through boiling. Nearly all participating mothers were acutely aware of the health risks associated with groundwater consumption, a sentiment consistently expressed across both study sites. Although community members perceived the well water as being of poor quality, potentially leading to illness, they continued to utilize it for drinking purposes, citing financial constraints: "*We can't always buy water*" (R67). Financial constraints, therefore, restricted the degree to which community members could respond to their awareness of poor water quality and the associated health risks from water-borne diseases.

Meanwhile, water storage emerged as a central theme in conversations with Kabul residents, underscoring its important role in shaping the physical environment for accessing clean drinking water. Interviews and observations indicated that variations in water storage practices across Kabul households substantially impacted experiences of water quality and the logistical context of water use, including the adoption of storage containers, their setup and maintenance, and water extraction – often stratified by wealth. The use of plastic water tanks and gallons already indicated the physical constraints faced by poorer households. However, the pronounced wealth disparity across Kabul households was even more apparent. In contrast to the laborious and precarious water storage among low-income families, the few affluent households seemed fully resilient to fluctuations in water availability. Sheltered and controlled storage conditions, as well as ownership of fridges, enabled them to retain access to quality drinking water during uncertain times (Q22). On the other hand, algal growth (worsened water quality), and increased maintenance – effectively raised costs and decreased water quality for financially strained households. A 48-year-old female respondent experienced algae growth in their water tanker and noticed the algae affected water quality (using the local notion of "*Jamanak* [جمنک]" and describing it as a "*green thing in water*"). Algal growth due to sunlight exposure required households to wash water storage tanks once or twice yearly, typically after summer (Q20). The water storage constraints burdened poor households with added labour and material costs for maintenance, insulation, and cleaning. Lower-income families often used plastic gallons, especially renters reluctant to buy expensive tanks since moves were frequent (Q21). The case of Q21 reflected other low-income households relying on small, portable plastic gallons, rather than home-based tanks, to fetch water from public sources. Though easily carried and affordable, these gallons needed washing every two days, proving more maintenance-intensive than permanent tanks.

An important household-level theme related to drinking water treatment behaviours – correlated only partly and imperfectly with wealth – was the available energy source for boiling water and the use of high-tech purifiers. Informants reported the predominant energy sources used for boiling drinking water were electricity, gas, wood, and, in some cases, plastic waste. While the latter may introduce other health hazards, reliance on electricity exposed households to interruptions in water treatment owing to frequent power outages observed during the study period. Such disruptions not only limited families' access to groundwater through pumps but also their ability to boil water. The frequent power outages produced three key outcomes: First, most households had to rely on gas for boiling water, though a 24-year-old female informant noted this would be economically infeasible for all members. Thus, many families only boiled water for sick individuals during outages. Second, poorer households resorted to using fires fuelled by plastic garbage or, if affordable, purchased water from trucks. However, trucking and bottled water were also constrained by electricity disruptions affecting the water supply (Q30). Finally, lacking alternatives, poorer households fetched water from distant public sources or consumed poor-quality well water until electricity was restored. As a 24-year-old interviewee explained that they were simply "*supposed to consume it* [well water].".

Beyond physical environment and economic factors, social dynamics, especially gender, also shaped water treatment patterns (aligning with "social opportunity" in COM-B). Analysis indicated that women performed common practices like boiling, straining, and chlorinating, as household managers, particularly in *peri*-urban areas (Q24). Men did other tasks, like washing tanks (R24). While gendered roles clearly influenced specific practices, gender perspectives also differed, indirectly influencing reflective motivation on water treatment. In some cases, interviews revealed men emphasized affordability, while women reflected more on experiences and long-term purification benefits. Both communities recognized these contrasts (for example, Q25). Household size also influenced water treatment. Our analysis suggested that participants perceived purchasing filters as viable for large families (R9) whereas small families preferred bottled water: "*Purifiers are expensive and good for big families. We buy mineral water for 40–50 AFN, which is purified*" (R28).

Another key characteristic generating systematically different experiences of water quality and treatment within and between the two communities was residency duration. On one hand, long-term Doghabad residents (15–20 years) noted changes in water quality compared to the past, unlike recent migrants (common in Bagrami). Their long-term experience enabled observations of degradation over time – for example, pit latrines contaminating groundwater (Q23). Here, long residency duration provided perspective to judge water quality – indirectly influencing reflective motivation on water-related behaviour – unavailable to recent arrivals (Q17). On the other hand, unsurprisingly, residency also systematically shaped site-specific realities of water access. In Doghabad, private companies provided clean drinking water from deep aquifers, yet most households relied on contaminated shallow wells and handpumps. Despite *E. coli* contamination, households did not adopt piped water until wells dried up. In contrast, Bagrami struggled especially with high salinity groundwater. Shared experiences of salty taste and waterborne diseases relegated shallow wells to such purposes as "*dishwashing, bathing, and toilet storage*" (R48). Thus, Bagrami households relied on trucked and bottled water for drinking, since well water "*makes us sick and we shouldn't use it*" (R42).

The depth at which well water is extracted also influenced households' perceptions of health risks and subsequent choices for water treatment methods. Water from deep wells (deeper than 60 mbgl) was generally considered fit for consumption compared to that from shallow wells (less than 40 mbgl). Explicit descriptions of the relationship between well depth and associated health risks were commonly observed (e.g., Q14 and Q15), reflecting the water-related experiences of the communities. Compared to households drawing water directly from a well, residents who switched to a private water network (sourced from

150 mbgl) generally perceived no need for additional treatment before consuming it as drinking water. A 51-year-old female respondent explained that the difference between a 150 m-deep well and a shallow 30 m well is that, "*When we used the* [shallow] *well water, we boiled it. We couldn't drink it unless it was boiled, but we use the water from the deep well without boiling, and there is no problem*" (R34). The water source and abstraction depth, as determined by the physical environment, therefore clearly influenced health risk perception and subsequent water treatment practices. Compounding the contextual role of abstraction depth, poverty and recent migration to the study sites also shaped the amount of information available to households (e.g., about the degree of contamination of local water sources) to mitigate water-related health risks (Q18).

5. Discussion

Access to clean drinking water is a basic human need and right (UN, 2010). Systematic reviews of WASH interventions have demonstrated the impact on reducing diarrheal diseases and microbial contamination (Clasen et al., 2015; Fewtrell et al., 2005; Martin et al., 2018; Wright et al., 2004). In response to the surprising emphasis placed on (only) psychological factors in the behavioural water literature, the objective of this study was to explore the factors determining household water treatment from a COM-B model perspective. To this end, we conducted 68 semi-structured interviews across two sites in Kabul, Afghanistan. In this semi-arid *peri*-urban context with high levels of water contamination and frequent water scarcity, water was primarily sourced from private household sources (wells/hand pumps), public wells/hand pumps, bottled water, water trucks, and private supply networks. Available options for water treatment included boiling, high-tech filters, sand filtration, chlorination, and solar disinfection.

Our thematic analysis revealed complex local water realities shaped by a fragmented information landscape dominated by interpersonal communication and inequitable formal water-related information sources. This forced residents to rely on sensory and heuristic cues along with observed health outcomes to judge water quality. Associated practices of water storage, gender roles, and environmental, epidemiological, and economic variability further complicated households' options for plausible water treatment. Adopting these options followed not a one-off decision but rather a navigation of a complex, idiosyncratic, and obscure landscape of dynamic costs and benefits, competing with other livelihood priorities. Behaviours making treatment obsolete (e.g., buying clean water) and external interventions imposing specific solutions without considering underlying behaviours and barriers further complicated adopting these practices.

From a COM-B perspective, these findings highlighted that psychological factors such as reflective motivation do play an evident role in performing household water treatment. For example, residents demonstrated a clear reflective weighing of benefits and costs when choosing to boil water, indicating awareness of waterborne diseases and even in some cases microbial contamination. They articulated expectations of the relative efficacy of boiling to purify water and made reasoned decisions to attain at least *some* protection. Families' experience of waterborne diseases often triggered boiling water before drinking, and mothers especially appeared vigilant about such diseases, providing boiled water for children under five in most circumstances despite the challenge for low-income families. However, psychological capability more fundamentally (e.g., ability to read and write, or ability to make specific decisions or perform behaviours) did not appear to shape water treatment practices considerably, at least as far as this qualitative data enabled us to discern.

A range of other factors also influenced water treatment behaviours – both psychological and contextual, directly and indirectly. Among other psychological factors were elements related to automatic motivation, relating to the habit and impulse systems of the brain. These powerful yet subtle elements directly related to the water realities experienced by Kabul residents, where sensory markers and experiences with water-borne illnesses (both with strong emotional dimensions) dominated everyday water experiences. Subsequently, these also featured in assessments of efficacy for water treatment options like chlorination.

Contextual factors were salient as well. Social opportunity factors indirectly influence behaviour *via* reflective motivation by shaping the landscape of water-related information available to households. Gender norms also influenced reflective motivation insofar as social realities of water use shaped frames of reference to evaluate treatment practices, with cost considerations dominating for men and personal experiences and long-term considerations more pronounced among women. As a direct influencing factor, gender norms as a social opportunity determined who performed specific water behaviours (e.g., men cleaning tanks, women boiling water). Physical opportunity as a contextual dimension was similarly pronounced, with residence region shaping local water quality and treatment needs, and available drinking water options. More pressing were epidemiological, infrastructural, and environmental factors, with disease outbreaks, power outages, and droughts prompting uptake and discontinuation of treatment in the two study sites. If nothing else, the passing of time alone led residents to re-evaluate water treatment as their perception gradually became more tolerant of water-borne disease risks. In contrast, physical capability factors like age and functioning did not emerge as notable themes.

In combination, contextual factors determined an environment where families weighed the direct costs and benefits of treatment against competing priorities of fuel, food, household budgets, and childrearing. Another helpful consideration implicit in the COM-B model was that the "B" (behaviour) dimension drew attention to practices that made water treatment redundant – indicating that not only livelihood priorities competed with water treatment. Competing behaviours were also influenced by contextual and psychological factors, such as purchasing clean water from trucks in Bagrami since groundwater was saline (automatic motivation driven by sensory quality markers) and filters were unaffordable (physical opportunity). However, the COM-B model also has limitations, as less readily discernible yet qualitatively pronounced factors related to political influence on the water treatment portfolio emerged in the study sites. From a development perspective, short-term, emergency-focused delivery of water purifying interventions by NGOs and the government had unintended consequences, including discontinuation of household chlorine treatment. Furthermore, incentives and social obligation (i.e., respecting the requests of community leaders) were important (but favourable) in temporarily promoting interventions. It is important to note that, in terms of practical applications, COM-B is mostly used by applied psychologists, which tends to produce a body of evidence focused more on psychological dimensions and individual responses, like RANAS. Additionally, unlike the predefined factors of closed-ended RANAS model, the open-ended structure of COM-B necessitates preliminary qualitative research to define its factors (Hamidi et al., 2023b).

Our findings resonate with past research by Daniel et al. (2021, 2020), and Dreibelbis et al. (2013), stressing socioeconomic, contextual, and technological factors besides psychological drivers of household water treatment. However, those approaches are limited by relying on quantitative analysis through the lens of the limited model (like RANAS), focused solely on psychological factors.

More importantly – and in light of the research objective – the critical role of contextual factors, competing priorities, and alternative behaviours in this qualitative study runs contrary to studies foregrounding psychological factors including: Inauen et al. (2013); Lilje and Mosler (2017); Lilje and Mosler (2018); Mosler (2012); and Mosler and Contzen (2016). While contextual factors may indirectly influence psychological drivers, their salience here underscores the need to investigate overlooked contextual dimensions of water behaviours across geographies, even where psychological drivers were previously detected. Accidentally omitting contextual drivers risks ineffective interventions, like promoting chlorine in Kabul based solely on psychosocial factors, as presented in Lilje and Mosler (2018), would fail due to not addressing site-specific challenges (e.g., salinity, yellow colour, tea scum), ignoring access to water quality information, low level of risk perception among households, and lack of access to cost-effective household water treatment technique (suitable for realities of household's socio-economic status in Kabul).[1]

The findings of this study have implications for development efforts, particularly in regions with water quality and sanitation challenges. We emphasize the critical importance of adopting a multifaceted approach that takes into account the interplay of psychological, contextual, and sociocultural factors that shape household water treatment behaviours. While addressing individual behaviours is essential, equally important is to acknowledge and address the broader environmental and societal context. Such an approach includes tailoring interventions to the specific challenges faced in a region, recognizing the influence of gender norms, improving the dissemination of information (ensuring water quality information reaches community members, particularly women of households), and understanding the competing priorities of households – here, the COM-B approach plays a pivotal role in determining the relevant underlying factors. The practical implication of our study in the case of Kabul city, from a COM-B perspective, includes informing initiatives aimed at improving clean water use in Kabul (faithful to local realities). For instance, effective interventions should involve community members (particularly women), leaders, and religious scholars (social opportunity, automatic motivation [legitimate "messengers"]) throughout design and implementation. Equally important is targeting motivation and physical opportunity via affordable, effective technologies resilient to disruptions and addressing local risk perceptions (i.e., local production of ceramic filters).

The limitations of this research pertain to conducting semi-structured interviews during intense conflict around Afghanistan (May-July 2021), which had a small effect on depth as some declined participation due to security concerns. COVID-19 restrictions also slightly limited interactions. Nevertheless, diverse voices were included through purposeful sampling (e.g., following local customs and interviewing participants in light of prevailing gender norms) and replacing decliners with individuals of similar characteristics. As an interview-based rather than long-term observational study, post-hoc reasoning is a limitation as respondents may make sense of decisions retrospectively (Smith, 2008). However, led by a local scholar familiar with the water context mitigated this by using broad questions about context and the decision-making process without requiring people to directly state what drove them in a particular situation, complemented by non-participant observations during fieldwork. Finally, the sampling strategy involving two distinct *peri*-urban areas limit empirical generalization but not methodological generalization – the COM-B approach to uncover psychological and contextual drivers of household water treatment is broadly applicable. Further research across diverse geographies would elucidate common and distinctive drivers.

6. Conclusions

Microbially contaminated drinking water is a global challenge. To promote acceptance and regular long-term usage of household water treatment solutions, the "hardware" must be accompanied by a comprehensive behavioural change model. This paper based on 68 semi-structured interviews in two *peri*-urban study sites in Kabul to explore the factors determining household water treatment practices from the perspective of the most comprehensive behaviour change model (COM-B). We established that psychological factors such as reflective motivation play an important role in performing household water treatment. An aspect of context that was prominent was the physical opportunity, the region of people's residences unequivocally shaped the local quality and the need for water treatment, and alternative drinking water sources (e.g., if private water networks were not available). Factors related to the epidemiological, infrastructural, and environmental context were even more crucial for influencing people's household water treatment practices. For example, water-borne disease outbreaks, power outages, and droughts particularly contributed to the dynamics that prompted the adoption and abandonment of household water treatment options. Contextual factors were documented, for example, the social opportunity factors had an indirect influence on behaviour via reflective motivation as it shaped the types and nature of water-related information that was available to households. Physical and social factors were presented that influenced the environment in which families may not only weigh the direct benefits and costs of water treatment but had to consider altogether competing priorities as well. For instance, the use of scarce fuel, limited household budgets for food, and the time requirements to raise a family and maintain the household all exacerbated challenges in navigating and negotiating water treatment options. The findings of this article through the COM-B lens revealed that its six dimensions help to formulate practical routes to delivering household water treatment intervention that is faithful to local realities. We documented that the complex interplay of factors – ranging from gender roles and household economics to infrastructure limitations – necessitates a holistic understanding and approach to promoting effective water treatment behaviours. We emphasize the need for interventions to be rooted in the local context, prioritizing community involvement, leveraging affordable and resilient technologies, and addressing overarching infrastructural challenges to ensure access to clean drinking water for all in water-insecure settings.

CRediT authorship contribution statement

Mohammad Daud Hamidi: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Marco J. Haenssgen:** Writing – review & editing, Visualization, Methodology, Formal analysis, Conceptualization. **H.Chris Greenwell:** Writing – review & editing, Supervision, Resources, Project administration, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We are thankful to Dr. Edward (Jed) Stevenson and Dr Milica Vasiljevic for their valuable discussions that contributed to the development and enhancement of this article. We are also grateful to Najma Arshadi and Alina Muradyar for their support in conducting interviews during MDH's fieldwork. We appreciate study participants for their generous dedication of time. This research was financed by the Global Challenges Research Fund at Durham University, which awarded a PhD scholarship to MDH. Additionally, MJH, MDH, and HCG were supported through a Royal Academy of Engineering Frontiers of Engineering for Development seed fund award (Ref. FoE2122\10\10). The funding body had no influence on the study design, nor on the collection, analysis, and interpretation of data, or the writing of the manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.

[1] While this limitation was salient in the original formulation of the RANAS model, subsequent applications, such as those by Daniel et al. (2021) and Callejas Moncaleano et al. (2021), have demonstrated greater awareness of such contextual factors.

org/10.1016/j.worlddev.2024.106902.

Data availability

Data will be made available on request.

References

Addo, I. B., Thoms, M. C., & Parsons, M. (2018). Household water use and conservation behavior: A meta-analysis. *Water Resources Research, 54*, 8381–8400. https://doi.org/10.1029/2018WR023306

Arriola, K. R. J., Ellis, A., Webb-Girard, A., Ogutu, E. A., McClintic, E., Caruso, B., & Freeman, M. C. (2020). Designing integrated interventions to improve nutrition and WASH behaviors in Kenya. *Pilot and Feasibility Studies, 6*. https://doi.org/10.1186/s40814-020-0555-x

Bestrowaterpurifier.in, 2017. 6 Easy Ways to Re-Use RO Waste Water [WWW Document]. URL https://www.bestrowaterpurifier.in/blog/ways-to-use-ro-waste-water/ (accessed 4.3.22).

Bitew, B. D., Gete, Y. K., Biks, G. A., & Adafrie, T. T. (2020). Barriers and enabling factors associated with the implementation of household solar water disinfection: A qualitative study in Northwest Ethiopia. *American Journal of Tropical Medicine and Hygiene, 102*, 458–467. https://doi.org/10.4269/ajtmh.18-0412

Blakely, T., Hales, S., Kieft, C., Wilson, N., & Woodward, A. (2005). The global distribution of risk factors by poverty level. *Bulletin of the World Health Organization, 83*, 118. https://doi.org//S0042-96862005000200012.

Cajka, J., Amer, S., Ridenhour, J., & Allpress, J. (2018). Geo-sampling in developing nations. *International Journal of Social Research Methodology, 21*, 729–746. https://doi.org/10.1080/13645579.2018.1484989

Callejas Moncaleano, D. C., Pande, S., & Rietveld, L. (2021). Water use efficiency: A review of contextual and behavioral factors. *Frontiers in Water, 3*, Article 685650. https://doi.org/10.3389/FRWA.2021.685650/BIBTEX

CDC, 2022. Household Water Treatment | Global Water, Sanitation and Hygiene [WWW Document]. URL https://www.cdc.gov/healthywater/global/household-water-treatment.html (accessed 8.15.22).

Charnley, J. (2021). Sustaining the water, sanitation and hygiene (WASH) behaviour change produced during schools-based interventions: Perspectives from East New Delhi primary schools. Annual review of education, communication, and language. *Sciences*, 20–53.

CIESIN. (2018). *Population Estimation Service, Version 3 (PES-v3)*. NASA Socioeconomic Data and Applications Center, 10.7927/H4DR2SK5.

Clasen, T., 2005. Household water treatment [WWW Document]. URL https://www.lboro.ac.uk/research/wedc/well/water-supply/ws-factsheets/household-water-treatment/ (accessed 5.27.22).

Clasen, T., Alexander, K., Sinclair, D., Boisson, S., Peletz, R., Chang, H., Majorin, F., & Cairncross, S. (2015). Interventions to improve water quality for preventing diarrhoea. *Cochrane Database of Systematic Reviews, 2015*. https://doi.org/10.1002/14651858.CD004794.pub3

Clasen, T., Nadakatti, S., & Menon, S. (2006). Microbiological performance of a water treatment unit designed for household use in developing countries. *Tropical Medicine & International Health, 11*, 1399–1405. https://doi.org/10.1111/J.1365-3156.2006.01699.X

Clasen, T., Schmidt, W.-P., Rabie, T., Roberts, I., & Cairncross, S. (2007). Interventions to improve water quality for preventing diarrhoea: Systematic review and meta-analysis. *BMJ, 334*, 782. https://doi.org/10.1136/bmj.39118.489931.BE

Creswell, J. W., & David, C. J. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (Fifth. ed.). Los Angeles CA: SAGE Publications Ltd.

Daniel, D., Diener, A., Pande, S., Jansen, S., Marks, S., Meierhofer, R., Bhatta, M., & Rietveld, L. (2019). Understanding the effect of socio-economic characteristics and psychosocial factors on household water treatment practices in rural Nepal using Bayesian Belief Networks. *International Journal of Hygiene and Environmental Health, 222*, 847–855. https://doi.org/10.1016/j.ijheh.2019.04.005

Daniel, D., Pande, S., & Rietveld, L. (2021). Socio-economic and psychological determinants for household water treatment practices in indigenous–rural Indonesia. *Frontiers in Water, 3*. https://doi.org/10.3389/frwa.2021.649445

Daniel, D., Pande, S., & Rietveld, L. (2020). The effect of socio-economic characteristics on the use of household water treatment via psychosocial factors: A mediation analysis. *Hydrological Sciences Journal, 65*, 2350–2358. https://doi.org/10.1080/02626667.2020.1807553

Dreibelbis, R., Winch, P. J., Leontsini, E., Hulland, K. R. S., Ram, P. K., Unicomb, L., & Luby, S. P. (2013). The Integrated Behavioural Model for Water, Sanitation, and Hygiene: A systematic review of behavioural models and a framework for designing and evaluating behaviour change interventions in infrastructure-restricted settings. *BMC Public Health, 13*, 1–13. https://doi.org/10.1186/1471-2458-13-1015

Ellis, A., McClintic, E. E., Awino, E. O., Caruso, B. A., Arriola, K. R. J., Ventura, S. G., Kowalski, A. J., Linabarger, M., Wodnik, B. K., Webb-Girard, A., Muga, R., & Freeman, M. C. (2020). Practices and perspectives on latrine use, child feces disposal, and clean play environments in western Kenya. *The American Journal of Tropical Medicine and Hygiene, 102*, 1094–1103. https://doi.org/10.4269/ajtmh.19-0389

Ewart McClintic, E., Ellis, A., Ogutu, E. A., Caruso, B. A., Gomez Ventura, S., Jacob Arriola, K. R., Kowalski, A. J., Linabarger, M., Wodnik, B. K., Muga, R., Freeman, M. C., & Webb Girard, A. (2022). Application of the capabilities, opportunities, motivations, and behavior (COM-B) change model to formative research for child nutrition in Western Kenya. *Current Developments in Nutrition, 6*. https://doi.org/10.1093/cdn/nzac104

Fewtrell, L., Kaufmann, R. B., Kay, D., Enanoria, W., Haller, L., & Colford, J. M. (2005). Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: A systematic review and meta-analysis. *The Lancet Infectious Diseases, 5*, 42–52. https://doi.org/10.1016/S1473-3099(04)01253-8

French, S. D., Green, S. E., O'Connor, D. A., McKenzie, J. E., Francis, J. J., Michie, S., Buchbinder, R., Schattner, P., Spike, N., & Grimshaw, J. M. (2012). Developing theory-informed behaviour change interventions to implement evidence into practice: A systematic approach using the Theoretical Domains Framework. *Implementation Science, 7*, 1–8. https://doi.org/10.1186/1748-5908-7-38/TABLES/3

GBD. (2019). *Global Burden of Disease Study 2019 (GBD 2019)*. Seattle, United States: Institute for Health Metrics and Evaluation (IHME).

Grais, R. F., Rose, A. M. C., & Guthmann, J.-P. (2007). Don't spin the pen: Two alternative methods for second-stage sampling in urban cluster surveys. *Emerging Themes in Epidemiology, 4*, 8. https://doi.org/10.1186/1742-7622-4-8

Haenssgen, M. J. (2019). *Interdisciplinary qualitative research in global development: A Concise Guide*. Bingley: Emerald Publishing Limited, 10.1108/9781839092299.

Haenssgen, M. J. (2015). Satellite-aided survey sampling and implementation in low- and middle-income contexts: A low-cost/low-tech alternative. *Emerging Themes in Epidemiology, 12*, 20. https://doi.org/10.1186/s12982-015-0041-8

Hamidi, M. D., Gröcke, D. R., Kumar Joshi, S., & Christopher Greenwell, H. (2023a). Investigating groundwater recharge using hydrogen and oxygen stable isotopes in Kabul city, a semi-arid region. *J Hydrol (Amst), 130187*. https://doi.org/10.1016/J.JHYDROL.2023.130187

Hamidi, M. D., Haenssgen, M. J., & Greenwell, H. C. (2023b). Determinants of household safe drinking water practices in Kabul, Afghanistan: New insights from behavioural survey data. *Water Research, 244*, Article 120521. https://doi.org/10.1016/j.watres.2023.120521

Hamidi, M. D., Kissane, S., Bogush, A. A., Karim, A. Q., Sagintayev, J., Towers, S., & Greenwell, H. C. (2023c). Spatial estimation of groundwater quality, hydrogeochemical investigation, and health impacts of shallow groundwater in Kabul city, Afghanistan. *Sustain Water Resour Manag, 9*, 20. https://doi.org/10.1007/s40899-022-00808-9

Inauen, J., Hossain, M., Johnston, R., & Mosler, H. (2013). Acceptance and use of eight arsenic-safe drinking water options in Bangladesh. *PLoS One1, 8*, Article e53640. https://doi.org/10.1371/journal.pone.0053640

KMARP, 2018. Health Report: TA 8969 AFG: Kabul Managed Aquifer Recharge. Kabul, Afghanistan.

Lantagne, D., & Clasen, T. (2012). Use of Household Water Treatment and Safe Storage Methods in Acute Emergency Response: Case Study Results from Nepal, Indonesia, Kenya, and Haiti. *Environmental Science & Technology, 46*, 11352–11360. https://doi.org/10.1021/es301842u

Lilje, J., & Mosler, H. (2018). Effects of a behavior change campaign on household drinking water disinfection in the Lake Chad basin using the RANAS approach. *Science of The Total Environment, 619–620*, 1599–1607. https://doi.org/10.1016/j.scitotenv.2017.10.142

Lilje, J., & Mosler, H. (2017). Socio-psychological determinants for safe drinking water consumption behaviors: A multi-country review. *Journal of Water, Sanitation and Hygiene for Development, 7*, 13–24. https://doi.org/10.2166/washdev.2017.080

Martin, N. A., Hulland, K. R. S., Dreibelbis, R., Sultana, F., & Winch, P. J. (2018). Sustained adoption of water, sanitation and hygiene interventions: Systematic review. *Tropical Medicine & International Health, 23*, 122–135. https://doi.org/10.1111/tmi.13011

McGuinness, S. L., O'Toole, J., Ayton, D., Giriyan, A., Gaonkar, C. A., Vhaval, R., Cheng, A. C., & Leder, K. (2020). Barriers and enablers to intervention uptake and health reporting in a water intervention trial in rural India: A qualitative explanatory study. *American Journal of Tropical Medicine and Hygiene, 102*, 507–517. https://doi.org/10.4269/ajtmh.19-0486

McPhail, A. A. (1993). The "five percent rule" for improved water service: Can households afford more? *World Development, 21*, 963–973. https://doi.org/10.1016/0305-750X(93)90054-D

Michie, S., Atkins, L., & West, R. (2014). *The behaviour change wheel : A guide to designing interventions* (1st ed.). Great Britain: Silverback Publishing.

Michie, S., Van Stralen, M. M., & West, R. (2011). The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implementation Science, 6*, 11.

Mosler, H. (2012). A systematic approach to behavior change interventions for the water and sanitation sector in developing countries: A conceptual model, a review, and a guideline. *International Journal of Environmental Health Research, 22*, 431–449. https://doi.org/10.1080/09603123.2011.650156

Mosler, H., Blöchliger, O., & Inauen, J. (2010). Personal, social, and situational factors influencing the consumption of drinking water from arsenic-safe deep tubewells in Bangladesh. *Journal of Environmental Management, 91*, 1316–1323. https://doi.org/10.1016/j.jenvman.2010.02.012

Mosler, H., Contzen, N., 2016. Systematic behavior change in water, sanitation and hygiene. A practical guide using the RANAS approach.

Mosler, H., Huber, A., & Bhend, S. (2011). Behavioural determinants of using fluoride removal filters in rural Ethiopia. *35th WEDC International Conference*.

Mubarak, M. Y., Wagner, A. L., Asami, M., Carlson, B. F., & Boulton, M. L. (2016). Hygienic practices and diarrheal illness among persons living in at-risk settings in Kabul, Afghanistan: A cross-sectional study. *BMC Infectious Diseases, 16*, 459. https://doi.org/10.1186/s12879-016-1789-3

NISA. (2020). *Estimated Population of Afghanistan 2020-21*. Kabul, Afghanistan: National Statistics and Information Authority.

Ochoo, B., Valcour, J., & Sarkar, A. (2017). Association between perceptions of public drinking water quality and actual drinking water quality: A community-based exploratory study in Newfoundland (Canada). *Environmental Research, 159*, 435–443. https://doi.org/10.1016/j.envres.2017.08.019

Okello, E., Kapiga, S., Grosskurth, H., Makata, K., McHaro, O., Kinungh, I. S., & Dreibelbis, R. (2019). Factors perceived to facilitate or hinder handwashing among primary students: A qualitative assessment of the Mikono Safi intervention schools in NW Tanzania. *BMJ Open, 9*, Article e030947. https://doi.org/10.1136/BMJOPEN-2019-030947

Planet Labs, 2020. High-Resolution Imagery with Planet Satellite Tasking [WWW Document]. URL https://www.planet.com/products/hi-res-monitoring/ (accessed 9.24.23).

QSR International. (2018). *Nvivo 12*. Doncaster: QSR International Pty Ltd.

Sigel, Dr.K., 2009. Household Survey on Environmental Sanitation. Leipzig, Germany.

Slekiene, J., & Mosler, H. (2019). The link between mental health and safe drinking water behaviors in a vulnerable population in rural Malawi. *BMC Psychol, 7*, 44. https://doi.org/10.1186/s40359-019-0320-1

Smith, K. (2008). Brain makes decisions before you even know it. *Nature*. https://doi.org/10.1038/NEWS.2008.751

Sobsey, M. D., Stauber, C. E., Casanova, L. M., Brown, J. M., & Elliott, M. A. (2008). Point of use household drinking water filtration: A practical, effective solution for providing sustained access to safe drinking water in the developing world. *Environmental Science & Technology, 42*, 4261–4267. https://doi.org/10.1021/es702746n

Sonego, I., Huber, A., & Mosler, H. (2013). Does the implementation of hardware need software? A longitudinal study on fluoride-removal filter Use in Ethiopia. *Environmental Science & Technology, 47*, 12661–12668. https://doi.org/10.1021/es402787s

Steinmo, S. H., Michie, S., Fuller, C., Stanley, S., Stapleton, C., & Stone, S. P. (2016). Bridging the gap between pragmatic intervention design and theory: Using behavioural science tools to modify an existing quality improvement programme to implement "Sepsis Six. *Implementation Science, 11*, 1–12. https://doi.org/10.1186/S13012-016-0376-8/TABLES/3

Tamene, A. (2021). A qualitative analysis of factors influencing household water treatment practices among consumers of self-supplied water in rural Ethiopia. *Risk Manag Healthc Policy, 14*, 1129–1139. https://doi.org/10.2147/RMHP.S299671

UN. (2010). *The human right to water and sanitation*. Treaty Series.

UNICEF/WHO. (2006). *Core questions on drinking-water and sanitation for household surveys*. Geneva: World Health Organization.

Webb, T. L., & Sheeran, P. (2006). Does changing behavioral intentions engender behavior change? A meta-analysis of the experimental evidence. *Psychological Bulletin, 132*, 249–268. https://doi.org/10.1037/0033-2909.132.2.249

West, R., & Michie, S. (2020). A brief introduction to the COM-B Model of behaviour and the PRIME Theory of motivation. *Qeios*. https://doi.org/10.32388/WW04E6.2

WHO, 2022. Drinking-water [WWW Document]. URL https://www.who.int/news-room/fact-sheets/detail/drinking-water (accessed 5.26.22).

WHO. (2010). Process of translation and adaptation of instruments. *World Health Organization*.

Wright, J., Gundry, S., & Conroy, R. (2004). Household drinking water in developing countries: A systematic review of microbiological contamination between source and point-of-use. *Tropical Medicine and International Health, 9*, 106–117.

Wutich, A. (2006). *Effects of Urban Water Scarcity on Sociability and Reciprocity in Cochabamba*. Bolivia: University of Florida.