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Determinants of household safe drinking water practices in Kabul, Afghanistan: New insights from behavioural survey data

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ABSTRACT

More than 2 billion people worldwide lack access to safe drinking water. Household water treatment (HWT) is an interim option for reducing the risk of water born disease. Understanding the factors that influence HWT behaviour is crucial for delivering successful interventions aimed at scaling relevant technologies, but the literature tends to emphasise psychological determinants with little consideration of socioeconomic and contextual factors. This article responds to this literature by using the COM-B model to examine the determinants of HWT practices through a comprehensive and context-sensitive behaviour definition. We informed this model through a cross-sectional survey design in which we collected data from 913 households in two peri-urban neighbourhoods of Kabul, Afghanistan. Our findings from descriptive statistical and regression analysis highlight the importance of not only psychological but also socio-economic and contextual determinants of HWT behaviour: Especially the COM-B dimensions of reflective and automatic motivation, and physical opportunity – which are heavily influenced by local context and economic circumstances – had statistically significant associations with performing HWT. The practical significance of these dimensions was similarly pronounced. For example, an increase in the physical opportunity index by 0.1 units from an average value of 0.7 to 0.8 would be associated with a 7.7 percentage-point higher likelihood of HWT performance. These results suggest that the COM-B model can be utilised to systematically design interventions aimed at promoting HWT practices, while highlighting the need to broaden behavioural analyses of HWT and consider contextual factors to develop interventions that are tailored to the specific needs and obstacles of different communities.

1. Introduction

Access to safe drinking water is a human right, yet over 2 billion people worldwide lack access to clean drinking water and consume water contaminated with faecal matter (WHO, 2022). Such microbiological contamination poses the greatest threat to the safety of drinking water, and can lead to waterborne diseases, with a higher rate in low-income populations (Adelodun et al., 2021). For instance, diarrhoea caused 1.5 million deaths in 2019 and is the eighth leading cause of mortality globally (WHO, 2020). The impact of waterborne diseases is particularly devastating for children. In Afghanistan, for example, waterborne diseases are a major contributor to child mortality, with one in four children dying before the age of five due to preventable illnesses caused by contaminated water (UNICEF, 2021).

A range of household water treatment solutions have been proposed to tackle this global challenge. amongst those, ceramic and biosand filters are deemed the most effective and practical solutions at the point-of-use in low- and middle-income countries (Sobsey et al., 2008). These household water treatment methods have the potential to be adopted broadly and can help prevent the spread of disease and reduce mortality from waterborne diseases (Clasen et al., 2007). However, the importance of water treatment is not limited to technical solutions but ultimately to its effective use, which links any solution also to the socio-economic realities of its users.[1] In line with this, previous research has repeatedly emphasised that providing household water treatment solutions alone is insufficient: For an effective intervention at

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[1] The importance of understanding the factors that influence behaviour in delivering successful interventions and scaling relevant technologies has been acknowledged by the Water Research journal, as evidenced by the inclusion of interdisciplinary articles that explore behavioural perspectives. See, for example, Poortvliet et al. (2018), Skura and Tyllianakis (2018), and Simha et al. (2018).

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the point of use, the "hardware" of water treatment technology must be accompanied by a comprehensive behavioural change model to foster adoption and regular usage over the long term (Lilje and Mosler, 2017; Sonego et al., 2013).

To better understand the factors influencing water, sanitation, and hygiene (WASH) practices and to increase the uptake of WASH interventions, several behavioural models with varying degrees of specificity have been developed. For instance, recent systematic reviews proposed a comprehensive and open-ended Integrated Behavioural Model for Water, Sanitation, and Hygiene (IBM-WASH) by taking into account psychosocial, contextual, and technological dimensions of WASH-related behaviour at different levels spanning the societal/structural, community, household, individual, and habitual levels (Dreibelbis et al., 2013; Martin et al., 2018). Although this assortment of components seems realistic, the exact manifestation of the model's components and their true scope are still disputed. Some scholars argue that psychological variables are the primary predictors of household water treatment behaviour, which is especially reflected in the influential RANAS (Risks, Attitudes, Norms, Abilities and Self-regulation) model that has shaped approaches to WASH-related behaviour change across several low- and middle-income countries (Lilje and Mosler, 2018, 2017; Mosler, 2012; Mosler et al., 2011, 2010; Sonego et al., 2013).

While developers of the RANAS behaviour model have discarded the importance of incorporating socio-economic and contextual factors in water-related behaviour models (Contzen et al., 2023; Lilje and Mosler, 2018, 2017), a recent quantitative study has highlighted a significant association of socio-economic factors with household water treatment behaviour (Daniel et al., 2021, 2020, 2019). Additionally, qualitative research by Tamene (2021) suggests the importance of interpersonal contact and social support, and Bitew et al. (2020) documented the barriers to implementing household water treatment (solar disinfection) including socio-cultural (i.e., inadequate information, parents paying less care), environmental (i.e., turbidity, geographical setting) and behavioural (i.e., mishandling treated water). For water practitioners and engineers working in low- and middle-income contexts (often afflicted by a confluence of political, economic, and social instability), it may come indeed as a surprise that the prevailing RANAS model places greater emphasis on psychological elements with less regard for context-specific socio-economic and cultural determinants of behaviour.

Alternative approaches are possible. A comprehensive and context-sensitive yet simple model of human behaviour is the COM-B model developed by Michie et al. (2011). This model was designed to guide behaviour change interventions and to overcome the paralysing diversity of behavioural models in the literature. Based on a ground-breaking systematic review of behaviour change techniques, the authors proposed the "behaviour change wheel" (BCW), which responds to enablers and barriers to a behaviour, such as household water treatment, across three dimensions: Capability (physical and psychological), Opportunity (physical and social), and Motivation (reflective and automatic). The widespread application of the COM-B model around the world has nurtured our knowledge about contextual behavioural drivers and associated interventions to change behaviour in areas as varied as public health, personal finance, or energy consumption (French et al., 2012; Michie et al., 2014; Steinmo et al., 2015). For example, Ellis et al. (2020) and Ewart McClintic et al. (2022) used the COM-B model in western Kenya to identify the drivers of nutrition and WASH behaviours, revealing that a lack of social support and opportunities to actually engage in healthy diets and handwashing were the biggest obstacles of behaviour change. The COM-B model may similarly be applied to water treatment behaviour on the household level, which could offer important and context-sensitive insights for the design of interventions in low- and middle-income countries. Yet despite its potential, applications of COM-B to water-related behaviours remain scarce.

Thus far, knowledge on the factors determining household water treatment is dominated by the psychological RANAS and existing WASH models. The work by Daniel et al. (2021) highlighted an interesting aspect: the RANAS model lacks explicit inclusion of contextual factors. Daniel et al. (2021) used Bayesian Belief Networks (BBN) to analyse the impact of external factors on RANAS domains and, ultimately, on HWT. In contrast, the COM-B model integrates external factors from the outset, emphasizing their role in behaviour. As a result, unlike the RANAS model, analysts using the COM-B model will always be required to at least take into account the variety of external social and physical contextual factors that influence water treatment behaviour both directly and indirectly (for example, through their impact on reflective motivation or personal physical capability). While COM-B does not specify specific factors for water treatment behaviour ex ante unlike RANAS, its domains allow for bottom-up adaptation to different contexts and behaviours. This highlights the value of incorporating the COM-B model as an approach to enhance existing analytical frameworks. This paper will use the more comprehensive and context-sensitive definition of the COM-B model to examine factors influencing household water treatment in Kabul, Afghanistan, as a high-priority and low-income water insecurity context. As part of a broader mixed-method research project, a preceding exploratory stage of qualitative research (reported elsewhere) in our study sites had established that contextual factors (physical and social opportunity) as well as people's motivation (automatic and reflective) appeared to play an important role in household water treatment. The objective of the current quantitative study is to examine the relative importance of the COM-B dimensions influencing household water treatment behaviour in Afghanistan, especially with respect to the disputed role of the contextual drivers of behaviour. The findings of this study are crucial for developing effective interventions to improve household water treatment behaviour and reduce the burden of water-borne diseases in Kabul.

2. Methods

2.1. Research design and study setting

This study aimed to investigate the factors influencing household water treatment behaviour in two peri-urban communities in Kabul, Afghanistan. The selection of Afghanistan as a priority setting for household water treatment behaviour was due to its worrying child mortality statistics: in 2020, the mortality rate amongst children under the age of five was 58 per 1000 live births, and 49.4% of the population living below the National Poverty Line of less than $2 income/day (ADB, 2022). The ongoing conflict in Afghanistan during the study period (May-July 2021) also had a significant impact on household welfare.

Within Kabul, we selected the two peri-urban districts of Doghabad and Bagrami as study sites, owing to their high rates of water-borne diseases and ethnically diverse populations (note that the study was not designed for the direct comparison of the two sites, but the inclusion of more than one site created additional contextual variability to better understand household water treatment behaviours). Doghabad had a population of 50,000 and was characterized by high microbial contamination, while Bagrami had a population of 100,000 and saline water (CIESIN, 2018; NISA, 2020). The prevalence of water-borne diseases was higher in Bagrami and included Amoebic dysentery, hepatitis A, typhoid & Paratyphoid, Shigellosis, and Salmonellosis (KMARP, 2018). In addition, the average depth of shallow groundwater in Bagrami was 3–7 m while the range for Doghabad was 25–35 m (Hamidi et al., 2023).

As part of a larger mixed-method research project on household-level water treatment in Kabul, this paper presents the quantitative component involving a survey research design with a cross-sectional two-stage cluster random sampling strategy to select a representative sample of households in the two study districts. The two-stage sampling approach involved first the purposive selection of the two study sites, followed by a probabilistic and satellite-aided selection of households (one respondent per household, see next section for details). The data were collected from May to July 2021 and resulted in a sample of 497 individuals in Doghabad and 416 individuals in Bagrami.

2.2. Sampling

The absence of detailed secondary household and behavioural survey data in Afghanistan required us to collect original survey data. To support the purposive selection of our study communities in the first sampling stage, we used a secondary data set from the Kabul Managed Aquifer Recharge project (KMARP, 2018) to identify two peri-urban sites with high rates of water-borne diseases and the number of people served by health centres. The distance of the peri-urban areas from the city centre and proximity to a local police station were also considered to ensure the safety of team members and quick response in uncertain situations.

The second stage of probabilistic household representative selection in the two study sites had to respond to the problem of missing sampling frames – the last nationwide population and housing census was conducted in 1979 – which is a common challenge in low- and middle-income country research. However, the recent advances in global positioning systems, geographic information systems (GIS), and remote sensing technologies provided an opportunity for a spatial sampling approach that was capable of overcoming this constraint (Galway et al., 2012; Haenssgen, 2015; Johnson, 2019). Following a combination of approaches used by Grais et al. (2007), Shannon et al. (2012), and Cajka et al. (2018), we used ArcGIS 10.8 (ESRI, 2021), high-resolution satellite imagery provided by the Afghanistan National Statistics and Information Authority (NISA), and an Open Street Maps layer to guide our random sampling strategy. The two peri-urban sites were divided into grids of 600×600 m, the centre of which was set as starting point for each sampling cluster.

In total, 10 sampling clusters were established in Bagrami and 11 in Doghabad (see Fig. 1). A team of 17 surveyors were deployed to each starting point. From the starting point, the closest house was interviewed first, and each house on alternating sides of the following streets was invited to participate in the survey until the survey team would arrive back at the starting point in the grid.[2] A household was defined as a shared kitchen and a residence of at least six months prior to the survey. A double monitoring procedure to maintain data quality involved surveyors monitoring each other's work and a supervisor overseeing the survey teams to ensure their safety and smooth delivery of the survey. Furthermore, the survey team leader regularly received reports from the survey team to monitor progress and survey quality.

2.3. Data collection

The survey questionnaire (Supplementary Material 1) was informed by the literature on access to water and household water treatment practices from Mubarak et al. (2016), Sigel (2009), UNICEF/WHO (2006), and Wutich (2006). The questionnaire also drew from behaviour change frameworks developed by Michie et al. (2014), Ochoo et al. (2017), Addo et al. (2018), Lilje and Mosler (2018), and Slekiene and Mosler (2019). Prior to the current study, we conducted exploratory qualitative research (not reported here) to identify relevant local water treatment behaviours and to establish the general suitability of COM-B as an analytical framework in the context of peri-urban Kabul.

The questionnaire was divided into seven sections, covering topics such as water use and storage, knowledge of water quality, health risks associated with poor water quality, knowledge of household water treatment, water treatment practices, COVID-19-related questions, and demographic information. The questionnaire was translated from English to local languages (Persian Dari and Pashto) and back-translated following best-practice recommendations for this type of research (Efstathiou, 2018). The Psychology Department Ethics Sub-committee at Durham University approved the ethics application (Reference: ES-2020–01–10T14:40:38-lgww95). To ensure proper project governance, the conduct of the survey was communicated to the head of the city district/village, the Imam of the mosque in the area, and the local division of Kabul police.

Participants from eligible households in two sampling areas were invited to take part in the survey, and the first available member of the household over the age of 18 was invited to participate (following informed oral consent). Questions on individual circumstances thereby pertained to individuals, but water access and treatment behaviour as well as related practices (e.g., water storage) applied at the household level. The face-to-face survey was conducted from May to July 2021. We administered the digital questionnaire on mobile phones using the survey software *Qualtrics* (Qualtrics, 2020), which provided both Persian Dari and Pashto language options. A team of 17 surveyors (12 female and 5 male) were recruited by Kabul University and received 3 days of training before conducting the survey on site. Before the survey, the questionnaire was piloted to ensure that questions were understandable to residents in both study areas, resulting in minor changes to question wording but not focus or structure.

2.4. Analysis

The questionnaire items mapped onto the six "COM" categories of the COM-B model: physical and psychological Capability, physical and social Opportunity, and reflective and automatic Motivation as illustrated in Fig. 2 (see Supplementary Material 2 for details on aggregated questionnaire items into COM dimensions). Further, six household water treatment questions were flagged as behaviours ("B"). Qualitative research prior to this survey helped us establish the relevance of these dimensions.

To identify the role of the "COM" factors in influencing household water treatment behaviours, this study employed descriptive statistical analysis and regression analysis on the community population sample. The analysis was divided into three stages:

Stage 1 **Study site context, and overview of the existing situation on household access to water, water storage and water treatment practices:** We used our primary survey data to establish a comprehensive understanding of the demographic and socio-economic situation in the study sites, given the general lack of detailed and up-to-date contextualising sources such as administrative statistics and secondary household survey data. Descriptive statistical analysis was employed to contextualize the sites at both household and site levels. Additionally, we documented the current state of water access, as well as the primary water storage and treatment methods used in households. This information was critical to the subsequent analysis of factors that influence household water treatment behaviour.

Stage 2 **Overview of COM factors determining household water treatment:** This step was analysed through bivariate analysis of the COM (Capability, Opportunity, and Motivation) factors associated with the performance of household water treatment (B). Each COM element in the questionnaire was normalized and recoded such that a value of [0] represented full disablement and [1] represented full enablement for the behaviour in question (for non-binary variables, this would correspond to a scale from [0] to [1] – from full disablement to full enablement). The item responses were normalized using Eq. (1):

[2] The rationale behind this close clustering of houses was the unstable security situation of Kabul at the time of the survey. As the survey did not capture geolocations and starting grid points, we treat this sample as a random walk in the remainder of this paper but are conscious that a small degree of spatial correlation may influence the clustering of standard errors.

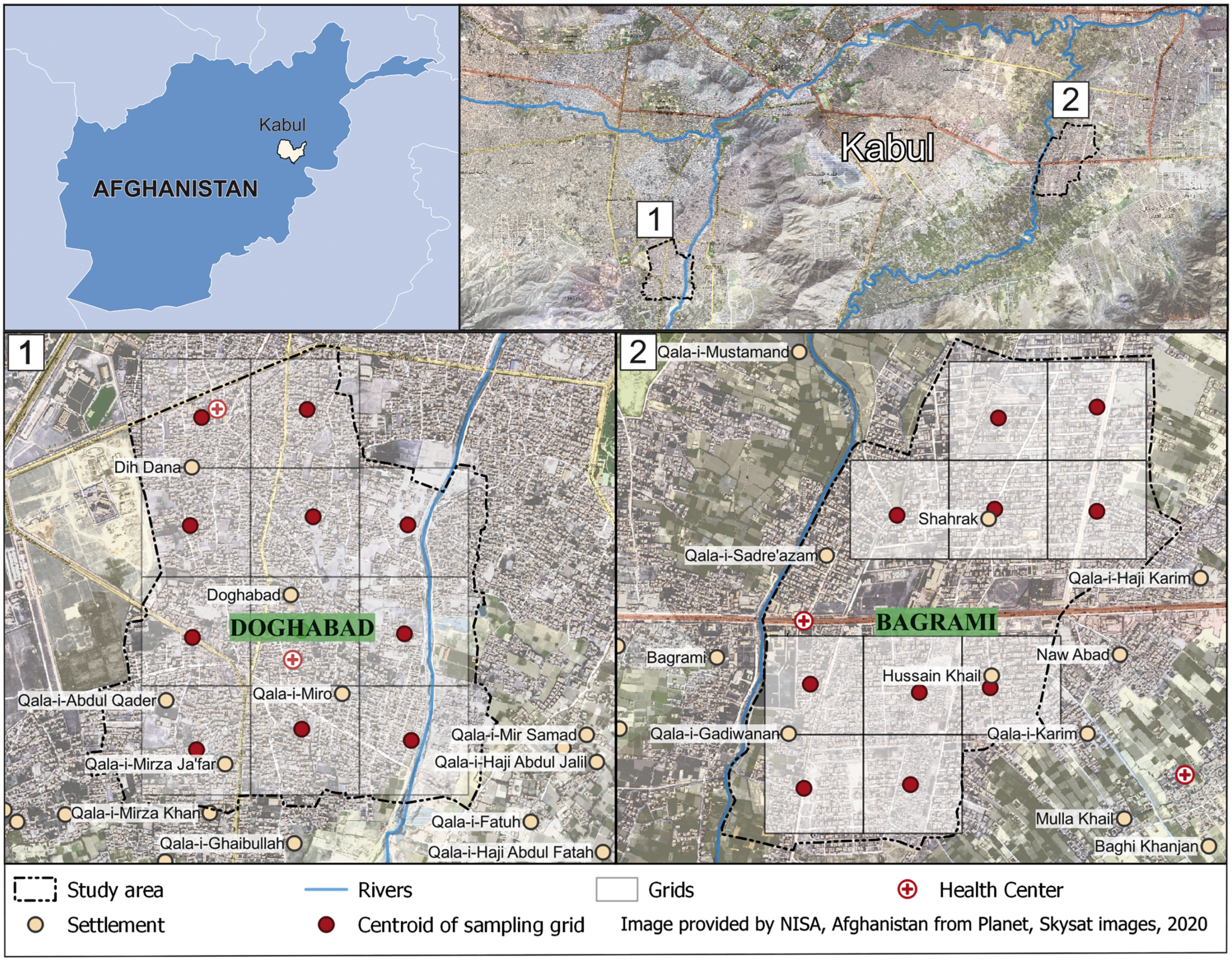

Fig. 1. Study area map and sampling grids.

$$X'_i = \frac{X_i - X_{min}}{X_{max} - X_{min}} \quad (1)$$

where X'_i is the normalized value of X_i (Witten et al., 2016). We then aggregated the elements into the six COM dimensions by averaging the normalized individual indicators into COM indices that again ranged from [0] (i.e., dimension fully disabled) to [1] (dimension fully enabled). The reporting presents the site-specific and overall mean values and 95% confidence intervals of item responses categorized in the COM dimensions, thus allowing us to characterise the configuration of common behavioural drivers in the study area. Furthermore, we used the Pearson χ^2 test for categorical variables and the Student's *t*-test for continuous variables to compare the significance of the difference in responses for each item between the two study sites.

Stage 3 **Relationship of "COM"-B model dimensions to performing household water treatment behaviours ("B"):** The final stage of the analysis examined and compared the relationship of the COM-B model dimensions (Capability, Opportunity, and Motivation) to the six identified household water treatment behaviours (B) as dependant variables. Each behaviour (B) constituted a model, and models 1 to 3 were chosen to be presented as the main focus of this article since they were relevant to delivering broader WASH interventions and the main objective of this article. First, we presented the bivariate analysis of the COM drivers of water treatment behaviour. Following bivariate analysis, we studied the relative contribution of each COM dimension to each of the six identified behaviours using multivariate regression analysis. To reduce complexity, we only used the six aggregate dimension indices as independent variables instead of the 37 disaggregated elements, principal component analysis or PCA was delivered to validate the COM dimension. Logistic regression was employed for behaviours that had binary responses, and linear regression was used for behaviours that had continuous (5-item Likert scale) responses.

Robustness checks involved sensitivity of the results to index construction (e.g., study site water quality including and excluding location) and considered the impact of the gender of the survey team on responses, given that most of the surveyors were female. In light of the lack of sampling frames and comprehensive population statistics, it was not possible to assign sampling weights to the survey responses. The analysis was conducted using Stata 17 (StataCorp, 2021).

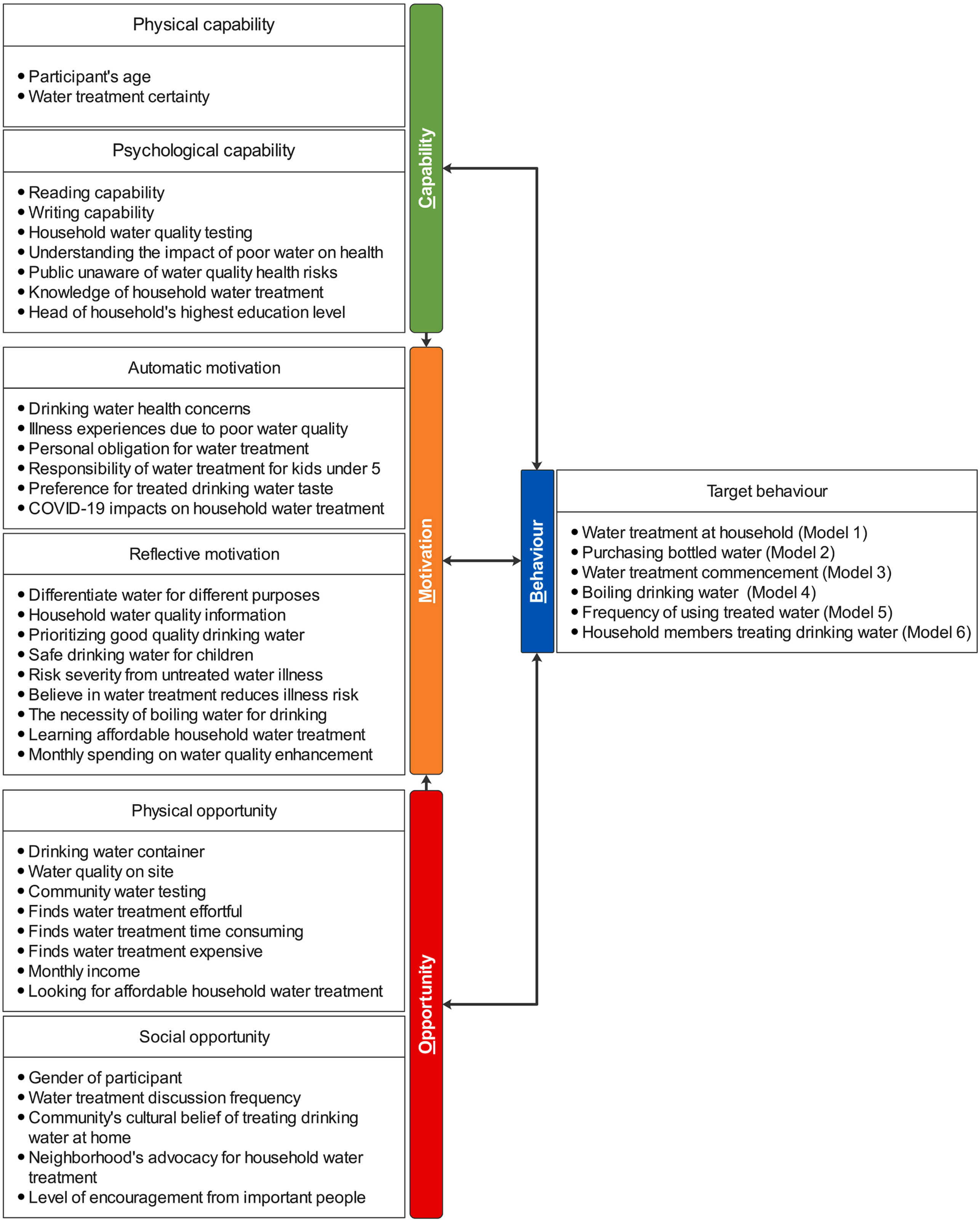

Fig. 2. Questionnaire items mapped into the six COM-B model categories.

3. Results

3.1. Study site context

The survey data indicated that the ethnically diverse sites had a relatively low average level of educational attainment amongst household heads, with approximately a quarter of them being illiterate both in Bagrami and in Doghabad (see Table S3 for details). An average household had eleven members and 46% of the surveyed households had a monthly income of less than 10,000 Afghanis (approx. $125). In addition, 48% of the households in Doghabad resided in the area for more than 10 years, compared to 23% in Bagrami.

The primary source of drinking water varied within and across the two study sites. Only 56% of the households in Doghabad had access to piped water from a private water supply network, 15% relied on deep groundwater wells, and shallow groundwater was the primary drinking water source for 14% of households. In Bagrami, the primary drinking water source for 35% of households was trucking water and 32% of households extracted water from deep groundwater wells for drinking purposes. To judge the quality of their water, respondents indicated a range of markers including taste (75% of households in Doghabad and 86% in Bagrami), as well as colour, odour, clarity, and presence of particles (Table S4).

The share of households who did not treat their water was statistically significantly higher ($p<0.001$) in Doghabad (50%) compared to Bagrami (34%), but both sites had a substantial minority who adopted water treatment in the past five years (21% in Doghabad and 41% in Bagrami). amongst those households who treated their water, the majority of Doghabad households (65%) boiled water, 19% used chlorination, and 15% used an advanced water purifier. In contrast, Bagrami commonly boiled water (46% of treating households) or used advanced water purifiers (30%). Households were also typically aware of different forms of water treatment that they chose not to perform (e.g., boiling water, chlorination and advanced water purifiers, see Table S5). Most households reported that they started using treated water for health reasons (59% in Doghabad and 69% in Bagrami), and participants generally showed a high rate of familiarity with waterborne health issues such as diarrhoea, H-Pillory, and kidney problems.

3.2. Overview of COM factors determining household water treatment

To study the factors influencing household water treatment, Table S6 documented the breakdown of questionnaire items into the Capability, Motivation and Opportunity (COM) dimensions of the COM-B model along a normalised scale from 0 to 1 (0 indicating perfectly disabling and 1 indicating perfectly enabling conditions to perform the behaviour). The highest sub-domain index value related to reflective motivation (0.798; 95% CI: 0.307–1.290), followed by physical capability and automatic motivation (0.736 [95% CI: 0.486–0.986] and 0.684 [95% CI: 0.278–1.091], respectively). Social opportunity received the lowest index value of 0.453 (95% CI: 0.349–0.558), meaning that it is more likely than other dimensions to act as a disabler of water treatment behaviour. amongst the individual elements across these dimensions, factors related to reflective motivation stood out. For example, nearly all participants agreed that regularly treating water reduces the risk of falling ill (0.966; 95% CI: 0.893–1.039) and that it should be everyone's responsibility to provide safe drinking water for children (0.977; 95% CI: 0.965–0.989). Similarly remarkable was automatic motivation, which also received higher mean values than other domains of the COM-B model. For example, most respondents confirmed a personal obligation to treat drinking water for children under the age of five years (0.823; 95% CI: 0.810–0.835) and that COVID-19 triggered more frequent water treatment before drinking water and cooking (0.721; 95% CI: 0.201–1.241). Other domains such as physical opportunity were less pronounced. However, also here individual elements constituted common enabling factors, for example, whether households owned a separate container for storing drinking water (0.791; 95% CI: 0.428–1.153).

Although the main objective of this study was not to compare the two sampling sites, statistically significant differences in the mean response of several factors demonstrated the variability of COM dimensions not only across households but also systematically across locations. For instance, Bagrami recorded higher mean responses to factors such as encouraging others to perform HWT, feeling worried about the health impacts of poor water quality, and willingness to pay. Only two factors had a higher mean value in Doghabad: the amount of effort needed and the cost of treating water. These site-specific conditions corresponded with the aforementioned variance in demographic, socio-economic, water source landscape, and household water treatment methods in the two study sites. Which of these conditions are relatively more decisive in directly shaping household water treatment will be the subject of the next section.

3.3. Relationship of COM dimensions to household water treatment behaviours (B)

This final step of our analysis examined the hypothesis that broader socioeconomic, psychosocial, and contextual factors shape household water treatment behaviour. To assess the relative importance of these COM dimensions on household water treatment behaviours, we used multivariate multiple regression and logistic regression models to identify the most influential determinants.

We first calculated bivariate relationships between all 37 items included in COM-B and the six main behaviours. The results, presented in Supplementary Material 7 (Bivariate.xlsx), highlight that all 37 items included in the COM-B model were significantly associated with at least one of the six identified household water treatment behaviours in bivariate analysis. Thus, we concluded that all items should remain in the model, but we reduced the subsequent multivariate analysis to the six component indicators of the COM-B model for simplicity and goodness-of-fit. Using regression analysis, the COM dimensions constituted the explanatory variables and three main behaviours served as outcomes for the main results presented in the remainder of this section (see Table S11 for supplementary outcome indicators): Treating water before drinking (Model 1), Using bottled water as main drinking water source (Model 2), and Household reports treating water in general (Model 3). Furthermore, PCA was used to validate the COM dimension, and a strong correlation was found between the PCA-generated indexes and the indexes created using mean values (see Supplementary Material 4 and Table S7). Additionally, the regression analysis of the PCA-generated COM indices and water treatment behaviours (Table S8) demonstrated a slight improvement in χ^2 and the Log Likelihood of the three main models, suggesting that the PCA-generated indices may provide a slightly better fit to the observed data. However, it should be noted that while PCA improved model performance, the resulting principal components remain less interpretable compared to the original variables. Therefore, to achieve the objective set earlier, we rely on the regression analysis of COM indices created from the mean values.

The results of the regression analysis are presented in Table 1 and make apparent that automatic and reflective motivation, physical opportunity and physical capability had a statistically significant association with household water treatment – immediately before drinking and in general (Models 1 and 3). For these two behaviours, social opportunity and psychological capability did not appear to have a significant link to household water treatment practices. Purchasing bottled water (Model 2) appeared to be an odd variation compared to Models 1 and 3: automatic and reflective motivation were positive and statistically significant for bottled water use as they were for water treatment. However, the capability dimension was not statistically significant, and, perhaps surprisingly at first glance, physical and social opportunity factors were statistically significant yet inversely related to using bottled water as the main drinking water source. These results can nevertheless be seen as plausible in context (and in relation to Section 3.1): trucking water was dominant and only available in one study site. This trucking water was less expensive and constituted a competing behaviour with other forms of household water treatment. Opportunity disablers for water *treatment* could therefore plausibly emerge as enablers for water *purchases*, while the purchase of water was less sensitive to personal capability factors (as opposed to other forms of access that would necessitate treatment), and in both cases households performing the behaviour might well follow the calculative and subconscious reasons that motivate clean drinking water use. Additional behaviours analysed

Table 1
Regression results of the relationship between COM indices and water treatment behaviours.

COM-B components	b_Q5_2 (**Model 1**) Do you treat water before drinking in your household? †	b_botwa (**Model 2**) Bottled water, the main source of drinking water†	Q5_4 (**Model 3**) When did you start treating water in your household? (Doers)†
Capability-Psychological	−0.010	−0.101	0.005
Capability - Physical	2.487***	0.205	1.298***
Opportunity - Physical	3.536***	−1.783**	4.049***
Opportunity - Social	0.534	−1.093*	0.436
Motivation - Reflective	2.725**	2.938**	3.777***
Motivation - Automatic	2.921***	2.331**	3.581***
Constant	−8.971***	−4.112***	−9.026***
χ^2	151***	36***	161***
Log Likelihood	−522	−383	−510
Observations	913	913	913

Notes: Logistic regressions. Coefficients reported.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.
† Binary outcome variables.

as consistency check and presented in the supplemental results showed similar relationships. The main results presented above excluded a site-specific effect that would capture for instance systematic variations in water quality. However, the inclusion of site-specific characteristics (water quality) contributed to household water treatment behaviour in a way that is most consistent with “physical opportunity,” and its separate inclusion as a dummy variable did not substantively alter the main results. Robustness checks of these results (presented in Table S13) using a site-fixed dummy variable and site-level clustering largely confirmed these results, although physical capability was sensitive to location.

This study was designed to determine the relative contribution of socioeconomic, psychosocial and contextual factors in explaining households’ water treatment behaviour. The factors with the most important influence on household water treatment were reflective and automatic motivation, and physical opportunity. Fig. 3 shows the marginal effects (with 95% CI) of reflective motivation and physical opportunity indexes on performing water treatment for models 1 and 3. Improved enablement of reflective motivation would coincide with a significantly higher likelihood of water treatment, as indicated by an increase in the index value from 0.8 to 0.9 with an associated 5.6 and 7.5 percentage-point increase in water treatment according to Model 1 and Model 3, respectively. Furthermore, an increase in the physical opportunity index value from 0.7 to 0.8 would result in a 7.3 or 7.7 percentage-point higher likelihood of household water treatment according to Model 1 and Model 3, respectively. These findings suggest that interventions aimed at promoting household water treatment may have a significantly positive impact if they targeted reflective motivation and physical opportunity, whereby the lower average index values of physical opportunity would indicate greater potential for improvement.

4. Discussion

4.1. Main findings

Identification of the socio-economic, psychosocial, and contextual determinants with the greatest impact on household water treatment behaviour is critical for the development of effective interventions and policies. Relying on the COM-B model as the most comprehensive framing of behaviour together with primary water behaviour data from peri-urban Kabul, this study highlighted the statistically significant associations of socioeconomic, psychosocial, and contextual determinants with household water treatment behaviours. From a COM-B perspective, the analysis suggested that reflective and automatic motivation, and physical opportunity were the most important behavioural drivers and had a statistically significant association with performing household water treatment behaviours.

For instance, related to contextual and socio-economic factors, the physical opportunity dimension showed significant associations with almost all models of household water treatment behaviours, highlighting the importance of issues such as site water quality, storage options, access to affordable treatment techniques, or household resources (time, material, financial) in performing household water treatment. Our findings align with the literature that emphasizes the contextual factors influencing household water treatment. Notably, wealth status was found to be significantly associated with household water treatment practices in Ethiopia, with higher-income households more likely to engage in such practices than low-income households (Geremew et al., 2018). Similarly, studies in rural Kenya indicated that the accessibility, ease of use, and cost of the product were determining factors of water treatment (Francis et al., 2015; Makutsa et al., 2001).

Additionally, the significant association of social opportunity with household water treatment practices in most of the models in this study highlighted the critical role of social influences (social norms, and talking to others about HWT), following other people performing HWT, and gender in water treatment. This resonates strongly with literature on the social context that thus far finds little recognition in the water behaviour sphere. For example, recent research on determinants of household water treatment suggested the importance of interpersonal contact and social support (Tamene, 2021). Likewise, Indigenous beliefs were found to be determining factor in the delivery of WASH interventions in Uganda (Okurut et al., 2015), and in treating water at the household level in Indonesia (Daniel et al., 2021).

Related to psychological factors, automatic and reflective motivation components of the COM-B model highlighted the association of factors such as worry, fear, traumatic experiences, perceived risk, and perceived benefit with performing water treatment. A key finding of our study was that a 10 percentage-point increase in cognitive enablers would coincide with a 7 percentage-point increase in the likelihood of water treatment at the household level. These findings are consistent with literature that emphasizes psychological factors, such as vulnerability, health knowledge, and the severity of water-borne diseases, having significant positive effects on household water treatment practices (Huber and Mosler, 2013; Lilje and Mosler, 2018). Also, the association of education and awareness about the HWT methods with performing household water treatment were highlighted by Admasie et al. (2022), DuBois et al. (2010), and Ibrahim et al. (2016). Household and demographic surveys in Egypt similarly stressed that households with heads who have

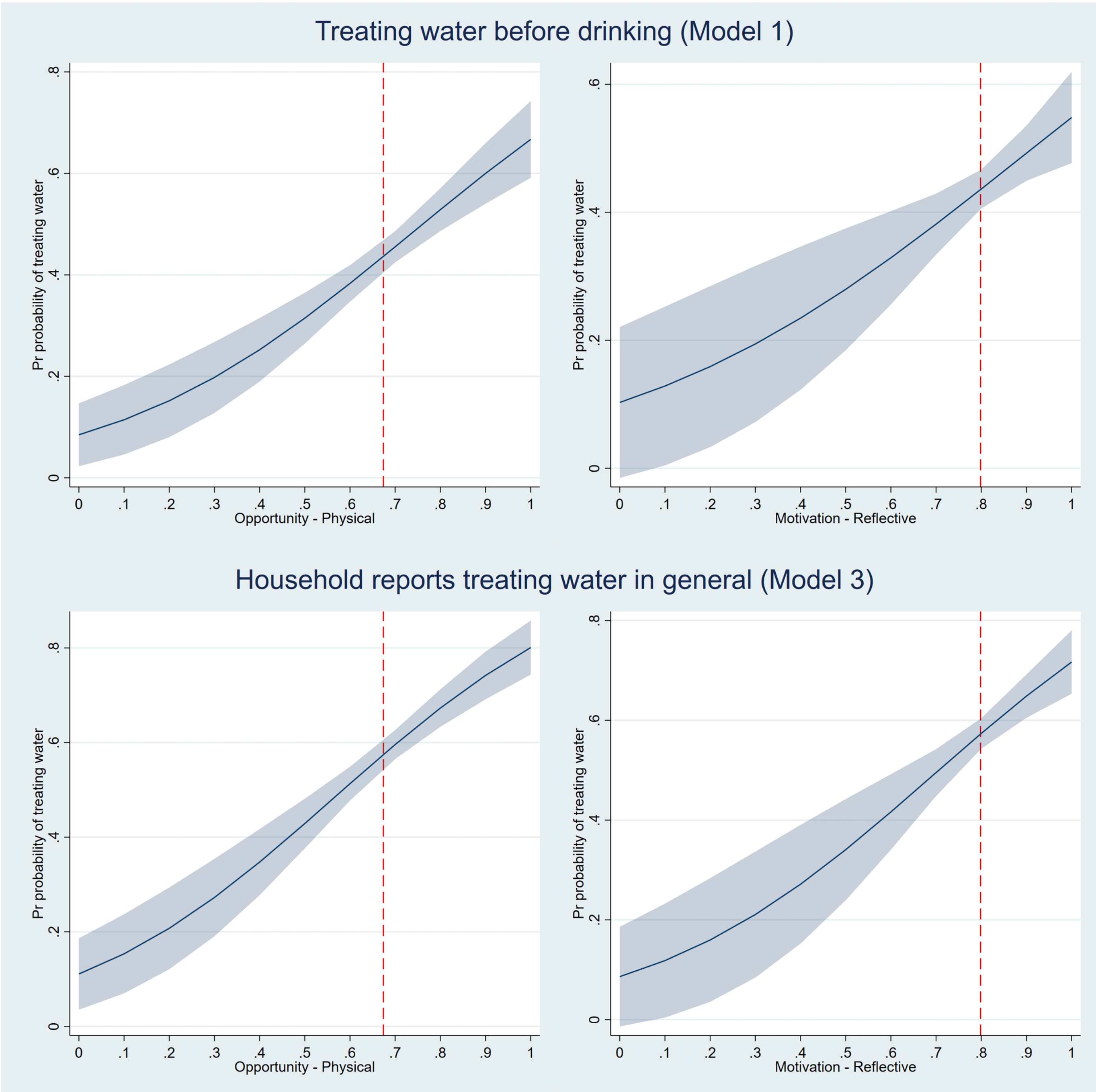

Fig. 3. Predictive margins of reflective motivation and physical opportunity with 95% CIs in Models 1 and 3.

completed at least primary school were more likely to perform HWT than those who have not (Wright and Gundry, 2009). However, in Nigeria, there was minimal difference in the likelihood of performing HWT between families where the heads have only received primary school education and those who have not (Abubakar, 2021).

Previous quantitative studies on the factors determining household water treatment emphasized the psychological determinants through the RANAS behaviour change model including Sonego et al. (2013); Mosler et al. (2010); and, Mosler et al. (2011). While developers of the RANAS behaviour model have underplayed the importance of including socio-economic and/or contextual factors in water-related behaviour models (Lilje and Mosler, 2018, 2017), the COM-B model acknowledges that for any behaviour to be carried out, people must have the capability, the opportunity, and be motivated to perform. All necessary enablers must be present, or the target behaviour would not change (West et al., 2019). Although there is necessarily some overlap in COM-B and RANAS dimensions, there is also considerable distinctiveness with regards to COM-B recognition of context and its process of applying it to a specific context. Therefore, one cannot be simply translated into the other. For instance, while the psychological capability and automatic and reflective motivation domains of COM-B are related to psychology, their impact on, and impact of other domains of COM-B (e.g., opportunity) cannot be easily translated into RANAS. On the other hand, the RANAS domains could be viewed as complementary to COM-B. As mentioned earlier, the reflective and automatic motivation aspects of the COM-B model are primarily associated with psychological domains and are in alignment with the RANAS model, which is solely a psychological model. However, it is essential to note that several factors within the physical opportunity domain of the COM-B model, along with certain factors in other domains, are influenced by socio-economic and contextual considerations. The RANAS model understates the significance of these factors, including education level, age, gender, access to resources, availability and affordability of technology, income level, beliefs, past experiences with water-borne diseases, access to water storage facilities, willingness to pay, community's demand for affordable household water treatment solutions, and competing priorities. The findings of our study suggest that the six dimensions of COM-B offer a more faithful and context-specific mapping of local water realities. The regression analysis suggested that reflective and automatic motivation, and physical opportunity were the most important and had a statistically significant association with performing household water treatment behaviours.

4.2. Limitations

The limitations of this research pertain to the delivery of this cross-sectional survey during the intense conflict period around Afghanistan in May-July 2021, which had a small effect on the depth of the research as some participants declined participation due to security concerns. Self-reported household water treatment behaviours could furthermore be subject to recall and social desirability biases that other data collection methods involving for instance participant observation might limit (Curtis et al., 1993; Halder et al., 2010). Our efforts to minimize self-report bias involved using various scales and having same-gender and student enumerators to reduce power imbalances, building trust with the community through prior qualitative research, and we did not require participants to recall specific instances of their behaviour but rather asked them to report their typical behaviour. However, self-reported bias remains a residual risk that future ethnographic research can help inform and overcome. Incorporating proxy behaviour observations and direct observations can be a valuable approach to reduce bias due to self-reported behaviour. However, implementing this approach was challenging in our case study area. Due to ongoing (and escalating) conflict, people tended to be more cautious and concerned about requests that involved observations inside their household. These concerns arise due to legitimate security considerations. However, as part of preliminary prior qualitative research with 68 semi-structured that helped ground the COM-B approach in the local context (reported elsewhere), we were also able to engage to a limited extent in non-participant observations of household water treatment. These qualitative insights provided important triangulation for our grounded interpretation of the survey results but are reported separately to focus the current manuscript specifically on the survey research.

Furthermore, mixed-gender student surveyor teams were employed to gain access to the community and build trust, especially given that women are typically responsible for household water treatment. However, using mixed-gender teams may also result in biased responses toward socially desirable answers based on the gender of the surveyor (Haber et al., 2018). Consistency checks to address this concern revealed no significant difference between mean responses for each COM-B domain based on surveyor gender (see Table S14).

Lastly, the sampling strategy involving two distinct peri-urban areas in Kabul metro also means that the results cannot speak easily to rural areas outside Kabul and those peri-urban with different contextual and environmental characteristics. While this limits the generalisability of the specific empirical findings, the methodological approach of the COM-B-based behavioural analysis to uncover psychosocial as well as other individual and contextual drivers of household water treatment practices is applicable more broadly.

4.3. Implications

This cross-sectional survey research offers implications for designing and implementing interventions aimed at promoting household water treatment in low- and middle-income countries. In contrast to the prevailing literature that primarily focuses on psychological factors, our findings established the important coexistence of socioeconomic, psychosocial, and contextual determinants of water treatment. From a COM-B approach perspective, reflective and automatic motivation and physical opportunity were found to be the most important drivers of household water treatment.

In order to target COM-B model components for behaviour change, particularly HWT, functions building on the Behaviour Change Wheel logic could include Persuasion, Training, and Enablement (Michie et al., 2011). For instance, Persuasion is an intervention function that targets an individual's beliefs, attitudes, or motivations towards a behaviour. Specific techniques include: using communication to spread information on the status quo of water quality and health risks of not performing HWT (e.g., sever water borne disease), raising awareness on the benefits of performing household water treatment, raising awareness on affordable HWT techniques (i.e., Ceramic water filters in the context of Kabul). Previous literature aligns with these recommendations, for instance, Thompson et al. (2018) applied Persuasion to promote gas stove use in rural Guatemala.

Training is an intervention function related that provides individuals with knowledge, skills, and practical experience to perform a behaviour effectively. Techniques related to HWT in the Kabul context could therefore include for instance training community members on testing water quality, training local actors including entrepreneurs on HWT methods and technology (e.g. local potters producing ceramic filters that are affordable, have proven efficacy in other geographies, and do not require energy), and establishing a mechanism for the distribution of filters amongst communities. The literature resonates with such recommendations as for example Bresee et al. (2016) have shown that training and education programs can increase the adoption of WASH behaviours.

Enablement is an intervention function that speaks to physical and social opportunity by removing barriers of and providing resources to support a desired behaviour. Such techniques could include targeting water-related information at the women in households who are mainly responsible for household water management (face-to-face and/or groups). Involving community members during the process and delivering the intervention, especially the local leaders, can be another pathway to fostering social opportunity, as might be the direct physical provision of access to affordable HWT methods like ceramic filters. That such approaches can bear fruit has been shown by Williams et al. (2020), who found enablement an important intervention function to promote the use of LPG gas stoves in Guatemala, India, Peru, and Rwanda.

5. Conclusion

Understanding the determinants of household water treatment behaviour is crucial for the development of effective interventions and policies. This study used the COM-B model to identify the most important socioeconomic, psychosocial, and contextual determinants associated with household water treatment behaviour. The results showed that physical opportunity, reflective and automatic motivation were the most important determinants in performing household water treatment behaviours. Our article also highlighted the critical role of social influences, such as social norms and gender, in water treatment. Our findings highlight the practical implications of utilizing the COM-B behaviour change approach, emphasizing its potential to inform the design and delivery of interventions that are tailored to the specific needs and realities of communities. It is important to acknowledge the complementarity between the RANAS and COM-B approaches, our results highlighted that the latter provides insights into contextual factors, thereby deepening our understanding of HWT determinants. It is crucial to acknowledge that deep-rooted political and historical factors can shape behaviour and influence responses to interventions (Bulled et al., 2017). Additionally, it is worth noting that COM-B is primarily employed by applied psychologists in terms of practical applications, resulting in a biased evidence base that predominantly focuses on psychological dimensions and individual responses, similar to RANAS. Furthermore, the open-ended nature of the COM-B framework necessitates qualitative groundwork to inform its categories, in contrast to the closed-ended RANAS framework that provides a predefined list of factors. Future research may examine this approach in other geographies and trial the viability of integrated, COM-B-based intervention designs to promote household water treatment.

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.

Data availability

Data will be made available on request.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.watres.2023.120521.

References

Abubakar, I.R., 2021. Understanding the socioeconomic and environmental indicators of household water treatment in Nigeria. Util. Policy 70, 1–10. https://doi.org/10.1016/j.jup.2021.101209.

ADB, 2022. Asian Development Bank; Poverty, Afghanistan [WWW Document]. URL. https://www.adb.org/countries/afghanistan/poverty. accessed 7.30.22.

Addo, I.B., Thoms, M.C., Parsons, M., 2018. Household Water Use and Conservation Behavior: A Meta-Analysis. Water Resour. Res. 54, 8381–8400. https://doi.org/10.1029/2018WR023306.

Adelodun, B., Ajibade, F.O., Ighalo, J.O., Odey, G., Ibrahim, R.G., Kareem, K.Y., Bakare, H.O., Tiamiyu, A.G.O., Ajibade, T.F., Abdulkadir, T.S., Adeniran, K.A., Choi, K.S., 2021. Assessment of socioeconomic inequality based on virus-contaminated water usage in developing countries: A review. Environ. Res. 192, 110309 https://doi.org/10.1016/J.ENVRES.2020.110309.

Admasie, A., Abera, K., Feleke, F.W., 2022. Household Water Treatment Practice and Associated Factors in Rural Households of Sodo Zuria District, Southern Ethiopia: Community-Based Cross-Sectional Study. Environ. Health Insights 16, 1–7. https://doi.org/10.1177/11786302221095036.

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. Am. J. Trop. Med. Hyg. 102, 458–467. https://doi.org/10.4269/ajtmh.18-0412.

Bresee, S., Caruso, B.A., Sales, J., Lupele, J., Freeman, M.C., 2016. 'A child is also a teacher': exploring the potential for children as change agents in the context of a school-based WASH intervention in rural Eastern Zambia. Health Educ. Res. 31, 521–534. https://doi.org/10.1093/her/cyw022.

Bulled, N., Matthew, P., Dutta, M.J., Basu, A., Gottlieb, S.D., Nading, A.M., 2017. Thinking Through resistance : a Study of Public Oppositions to Contemporary Global Health Practice.

Cajka, J., Amer, S., Ridenhour, J., Allpress, J., 2018. Geo-sampling in developing nations. Int. J. Soc. Res. Methodol. 21, 729–746. https://doi.org/10.1080/13645579.2018.1484989.

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

Clasen, T.F., Schmidt, W.P., Rabie, T., Roberts, I., Cairncross, S., 2007. Interventions to improve water quality for preventing diarrhoea: Systematic review and meta-analysis. Br. Med. J. 334, 782–785. https://doi.org/10.1136/bmj.39118.489931.BE.

Contzen, N., Kollmann, J., Mosler, H.J., 2023. The importance of user acceptance, support, and behaviour change for the implementation of decentralized water technologies. NPJ Clean Water 1, 138–150. https://doi.org/10.1038/s44221-022-00015-y.

Curtis, V., Cousens, S., Mertens, T., Traore, E., Kanki, B., Diallo, I., 1993. Structured observations of hygiene behaviours in Burkina Faso: validity, variability, and utility. Bull. World Health Organ. 71, 23.

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. Int. J. Hyg. Environ. 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. Front. 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. Hydrol. Sci. J. 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.

DuBois, A.E., Crump, J.A., Keswick, B.H., Slutsker, L., Quick, R.E., Vulule, J.M., Luby, S.P., 2010. Determinants of use of household-level water chlorination products in Rural Kenya, 2003-2005. Int. J. Environ. Res. Public Health 7, 3842–3852. https://doi.org/10.3390/ijerph7103842.

Efstathiou, G., 2018. Translation, Adaptation and Validation Process of Research Instruments. Springer International Publishing. https://doi.org/10.1007/978-3-319-89899-5_7.

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. Am. J. Trop. Med. Hyg. 102, 1094–1103. https://doi.org/10.4269/AJTMH.19-0389.

ESRI, 2021. ArcGIS Desktop: Release 10. 8.

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. Curr. Dev. Nutr. 6 https://doi.org/10.1093/cdn/nzac104.

Francis, M.R., Nagarajan, G., Sarkar, R., Mohan, V.R., Kang, G., Balraj, V., 2015. Perception of drinking water safety and factors influencing acceptance and sustainability of a water quality intervention in rural southern India. BMC Public Health 15, 1–9. https://doi.org/10.1186/S12889-015-1974-0.

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. Implement. Sci. 7, 1–8. https://doi.org/10.1186/1748-5908-7-38.

Galway, L.P., Bell, N., Al Shatari, S.A.E., Hagopian, A., Burnham, G., Flaxman, A., Weiss, W.M., Rajaratnam, J., Takaro, T.K., 2012. A two-stage cluster sampling method using gridded population data, a GIS, and Google Earth TM imagery in a population-based mortality survey in Iraq. Int. J. Health Geogr. 11, 1–9. https://doi.org/10.1186/1476-072X-11-12.

Geremew, A., Mengistie, B., Mellor, J., Lantagne, D.S., Alemayehu, E., Sahilu, G., 2018. Appropriate household water treatment methods in Ethiopia: Household use and associated factors based on 2005, 2011, and 2016 EDHS data. Environ. Health Prev. Med. 23, 1–11. https://doi.org/10.1186/S12199-018-0737-9.

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. Emerg. Themes Epidemiol. 4, 1–7. https://doi.org/10.1186/1742-7622-4-8.

Haber, N., Robyn, P.J., Hamadou, S., Yama, G., Hien, H., Louvouezo, D., Fink, G., 2018. Surveyor Gender Modifies Average Survey Responses: Evidence from Household Surveys in Four Sub-Saharan African Countries. https://doi.org/10.48550/arxiv.1810.01981.

Haenssgen, M.J., 2015. Satellite-aided survey sampling and implementation in low- and middle-income contexts: A low-cost/low-tech alternative. Emerg. Themes Epidemiol. 12, 1–10. https://doi.org/10.1186/s12982-015-0041-8.

Halder, A.K., Tronchet, C., Akhter, S., Bhuiya, A., Johnston, R., Luby, S.P., 2010. Observed hand cleanliness and other measures of handwashing behavior in rural Bangladesh. BMC Public Health 10, 545. https://doi.org/10.1186/1471-2458-10-545.

Hamidi, M.D., Kissane, S., Bogush, A.A., Qayeum, A.K., Sagintayev, J., Towers, S., Greenwell, H.C., 2023. Spatial estimation of groundwater quality, hydrogeochemical investigation, and health impacts of shallow groundwater in Kabul city, Afghanistan. Sustain. Water Resour. Manag. 9, 1–14. https://doi.org/10.1007/S40899-022-00808-9.

Huber, A.C., Mosler, H.J., 2013. Determining behavioral factors for interventions to increase safe water consumption: a cross-sectional field study in rural Ethiopia. Int. J. Environ. Health Res. 23, 96–107. https://doi.org/10.1080/09603123.2012.699032.

Ibrahim, J.M., Sufiyan, M.B., Olorukooba, A.A., Gobir, A.A., Adam, H., Amadu, L., 2016. Knowledge, attitudes, and practices of household water purification among caregivers of under-five children in biye community, Kaduna State. Archiv. Med. Surg. 1, 35.

Johnson, T.P., 2019. Advances in Comparative Survey methods : multinational, multiregional, and Multicultural Contexts (3MC), 1st ed. John Wiley & Sons, Inc, NJ.

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

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

Lilje, J., Mosler, H.J., 2017. Socio-psychological determinants for safe drinking water consumption behaviors: A multi-country review. J. Water Sanit. Hyg. Dev. 7, 13–24. https://doi.org/10.2166/washdev.2017.080.

Makutsa, P., Nzaku, K., Ogutu, P., Barasa, P., Ombeki, S., Mwaki, A., Quick, R.E., 2001. Challenges in Implementing a Point-of-Use Water Quality Intervention in Rural Kenya. Am. J. Public Health 91, 1571–1573. https://doi.org/10.2105/AJPH.91.10.1571.

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. Trop. Med. Int. Health 23, 122–135. https://doi.org/10.1111/TMI.13011.

Michie, S., Atkins, L., West, R., 2014. The Behaviour Change wheel : a Guide to Designing interventions, 1st ed. Silverback Publishing, Great Britain.

Michie, S., Van Stralen, M.M., West, R., 2011. The behaviour change wheel: A new method for characterising and designing behaviour change interventions. Implement. Sci. 6, 11.

Mosler, H.J., 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. Int. J. Environ. Health Res. 22, 431–449. https://doi.org/10.1080/09603123.2011.650156.

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

Mosler, H.J., Huber, A.C., Bhend, S., 2011. Behavioural determinants of using fluoride removal filters in rural Ethiopia. In: 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 Infect. Dis. 16 (9) https://doi.org/10.1186/s12879-016-1789-3.

NISA, 2020. Estimated Population of Afghanistan 2020-21.

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). Environ. Res. 159, 435–443. https://doi.org/10.1016/j.envres.2017.08.019.

Okurut, K., Kulabako, R.N., Chenoweth, J., Charles, K., 2015. Assessing demand for improved sustainable sanitation in low-income informal settlements of urban areas: A critical review. Int. J. Environ. Health Res. https://doi.org/10.1080/09603123.2014.893570.

Poortvliet, P.M., Sanders, L., Weijma, J., De Vries, J.R., 2018. Acceptance of new sanitation: The role of end-users' pro-environmental personal norms and risk and benefit perceptions. Water Res. 131, 90–99. https://doi.org/10.1016/j.watres.2017.12.032.

Qualtrics, 2020. Setting Up the Offline App [WWW Document]. URL. https://www.qualtrics.com/support/survey-platform/distributions-module/mobile-distributions/offline-app/setting-up-the-offline-app/. accessed 12.28.21.

Shannon, H.S., Hutson, R., Kolbe, A., Stringer, B., Haines, T., 2012. Choosing a survey sample when data on the population are limited: a method using Global Positioning Systems and aerial and satellite photographs. Emerg. Themes Epidemiol. 9, 5. https://doi.org/10.1186/1742-7622-9-5.

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

Simha, P., Lalander, C., Ramanathan, A., Vijayalakshmi, C., McConville, J.R., Vinnerås, B., Ganesapillai, M., 2018. What do consumers think about recycling human urine as fertiliser? Perceptions and attitudes of a university community in South India. Water Res. 143, 527–538. https://doi.org/10.1016/j.watres.2018.07.006.

Skuras, D., Tyllianakis, E., 2018. The perception of water related risks and the state of the water environment in the European Union. Water Res. 143, 198–208. https://doi.org/10.1016/j.watres.2018.06.045.

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

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. Environ. Sci. Technol. 42, 4261–4267. https://doi.org/10.1021/es702746n.

Sonego, I.L., Huber, A.C., Mosler, H.J., 2013. Does the Implementation of Hardware Need Software? A Longitudinal Study on Fluoride-Removal Filter Use in Ethiopia. Environ. Sci. Technol. 47, 12661–12668. https://doi.org/10.1021/es402787s.

StataCorp, 2021. Software Updates. Stata J 21, 847. https://doi.org/10.1177/1536867X211045584.

Steinmo, S.H., Michie, S., Fuller, C., Stanley, S., Stapleton, C., Stone, S.P., 2015. Bridging the gap between pragmatic intervention design and theory: using behavioural science tools to modify an existing quality improvement programme to implement "Sepsis Six. Implement. Sci. 11, 14. https://doi.org/10.1186/s13012-016-0376-8.

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.

Thompson, L.M., Diaz-Artiga, A., Weinstein, J.R., Handley, M.A., 2018. Designing a behavioral intervention using the COM-B model and the theoretical domains framework to promote gas stove use in rural Guatemala: a formative research study. BMC Public Health 18, 253. https://doi.org/10.1186/s12889-018-5138-x.

UNICEF, 2021. WASH: Water, Sanitation and Hygiene | UNICEF Afghanistan [WWW Document]. URL. https://www.unicef.org/afghanistan/wash-water-sanitation-and-hygiene. accessed 12.25.21.

UNICEF/WHO, 2006. Core Questions On Drinking-Water and Sanitation For Household Surveys. World Health Organization, Geneva.

West, R., Michie, S., Atkins, L., Chadwick, P., Lorencatto, F., 2019. Achieving Behaviour change, A guide For Local Government and Partners.

WHO, 2022. Drinking-water [WWW Document]. URL. https://www.who.int/news-room/fact-sheets/detail/drinking-water. accessed 9.20.22.

WHO, 2020. The Top 10 Causes of Death [WWW Document]. URL. https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death. accessed 9.21.22.

Williams, K.N., Thompson, L.M., Sakas, Z., Hengstermann, M., Quinn, A., Díaz-Artiga, A., Thangavel, G., Puzzolo, E., Rosa, G., Balakrishnan, K., Peel, J., Checkley, W., Clasen, T.F., Miranda, J.J., Rosenthal, J.P., Harvey, S.A., 2020. Designing a comprehensive behaviour change intervention to promote and monitor exclusive use of liquefied petroleum gas stoves for the Household Air Pollution Intervention Network (HAPIN) trial. BMJ Open 10, e037761. https://doi.org/10.1136/bmjopen-2020-037761.

Witten, I.H., Frank, E., Hall, M.A., Pal, C.J., 2016. Data Mining: Practical Machine Learning Tools and Techniques. Data Mining: Practical Machine Learning Tools and Techniques, pp. 1–621. https://doi.org/10.1016/C2009-0-19715-5.

Wright, J., Gundry, S.W., 2009. Household characteristics associated with home water treatment: an analysis of the Egyptian Demographic and Health Survey. J. Water Health 7, 21–29. https://doi.org/10.2166/WH.2009.056.

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