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PAPER

Psychological determinants of the adoption of a community-based drinking water purification technology in rural India

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Supplementary material for this article is available online

Abstract

Community-based water purification technologies provide a pathway to safe drinking water in rural India, where infrastructure and service reliability are often limited. This study investigates direct and indirect psychological determinants as well as contextual factors of adoption of Jivamritam, a community-based water purification technology, as a regular source of drinking water. Guided by a user-focused theory of change framework, cross-sectional survey data from 671 households across 40 communities in six Indian states were analyzed using generalized linear mixed models. Results revealed that five psychological determinants were significantly associated with adoption: perceived severity of waterborne disease (odds ratio [OR] = 1.74), perceived ease of access ($OR = 2.22$), perceived cost-effectiveness ($OR = 2.17$), perceived descriptive norms ($OR = 2.80$) and trust in the implementing agency ($OR = 2.14$). Among the contextual factors, assistance from family members was directly associated with adoption ($OR = 24.96$) as well as indirectly via perceived ease of access ($OR = 4.77$). Trust in the water committee was associated with adoption via perceived ease of access and perceived cost-effectiveness ($OR = 2.08$). Our findings emphasize the need to account for both direct and indirect behavioral pathways when seeking to understand water purification technology's adoption. Moreover, by quantifying these behavioral pathways, this study provides actionable, empirically grounded targets for interventions aimed at promoting the adoption of such technologies.

1. Introduction

Access to clean, affordable drinking water is a critical global aim [1]. Yet in 2022, there were still 2.2 billion individuals worldwide without access to safely managed drinking water, which poses significant health risks and majorly contributes to preventable deaths [2]. Increasing water scarcity due to climate change and population growth exacerbates this issue and calls for increased efforts to achieve universal water coverage by 2030 [3].

One of the countries experiencing extremely high-water stress is India [4], with an estimated 342 million people—approximately 24% of the national population—lacking access to safe drinking water in 2024 [5]. The situation is particularly dire in rural Indian communities, where centralized water infrastructure is often missing or has limited treatment capacity [6], and where consumption of untreated

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water is a major cause of disease and mortality as a result [7–9]. While both household water treatment and community-based water purification technologies may serve as alternatives for providing safe drinking water in these settings, the use of community-based technologies is considered easier to adopt as it usually requires less behavioral change than household water treatment [10–12]. Nevertheless, also community-based water purification technologies are often not consistently adopted [13, 14]. Therefore, a key question is how to effectively promote adoption.

A useful starting point for addressing this question is a theory of change (ToC), which outlines how and why change is expected to occur [15, 16]. In this context, the ToC would summarize the entire range of potential drivers and barriers of technology adoption [12, 17]—referred to here as psychological determinants and contextual factors of adoption—which are promising intervention targets. It would also include specific change techniques, the active ingredients of an intervention that are expected to promote adoption by changing the psychological determinants and contextual factors [12, 17, 18]. When planning an intervention in a specific context, such as rural India, one would first identify which psychological determinants and contextual factors outlined in the ToC explain adoption there, and then select change techniques from the ToC expected to change them.

A dominant ToC in the water, sanitation and hygiene (WaSH) sector in the Global South is the RANAS (Risk, Attitudes, Norms, Abilities, and self-regulation) model, which was specifically developed for planning behavioral interventions in this context [17]. Building on theories and evidence from social and particularly health psychology in the Global North, the model comprises five groups of determinants and related change techniques that are expected to increase adoption by changing those specific determinants, and which could be applied in interventions: (1) risk factors, such as perceived health risks of, for example, consuming non-purified water; (2) attitude factors, such as perceived costs and benefits of purification as well as affective reactions; (3) norm factors, namely social and personal norms sanctioning or supporting a given behavior; (4) ability factors, such as believing to have the necessary means to use a technology; and (5) self-regulation factors, such as planning the use and coping with barriers. In a revised version, the RANAS model also considers the contextual factors in which the psychological determinants and the behavior are embedded [19].

Although the RANAS model [17, 19] is widely used in the WaSH sector, to our knowledge, only three studies have applied it to explain the adoption of community-based water purification technologies in particular [20–22]. All of them focused on community-based fluoride-removal filters (see table 1). Huber and Mosler [21] first applied the RANAS model to examine filter use in rural Ethiopia, identifying (1) knowledge about fluorosis (i.e. a risk factor), (2) perceived good taste of the filtered water and perceived low distance to the community filter (i.e. attitude factors), and (3) commitment and remembering to use the community filter (i.e. self-regulation factors) as psychological determinants. A subsequent study in the same context extended this work, showing that filter use was explained by (1) perceived vulnerability of developing fluorosis (i.e. a risk factor), (2) perceived good taste and low price of the filtered water (i.e. attitude factors), and (3) behavioral control to fetch all the required water at the filter (i.e. an ability factor) [22]. Expanding the evidence base to a different setting, a third study conducted in Tanzania investigated willingness to pay for fluoride-removal filters, identifying (1) perceived health risk, specifically a combined measure of perceived vulnerability and severity of fluorosis (i.e. risk factors), and (2) attitudes, specifically a combined measure of perceived health benefits, time-consumption, and taste, as well as happiness (i.e. attitude factors) as psychological determinants [20]. In addition to these RANAS studies, research on safe water kiosks in Kenya [23] investigated a broad range of psychological determinants to explain adoption, covering many of the RANAS factors (see table 1). Regular kiosk use was (indirectly) explained by (1) perceived good quality of the kiosk water and low effort of fetching kiosk water (i.e. attitude factors), (2) perceived social norms to use the kiosk (i.e. norm factors), (3) perceived ability to fetch all water at the kiosk (i.e. ability factor), and (4) commitment to use the kiosk (i.e. a self-regulation factor).

Collectively, these studies provide initial evidence on the psychological determinants of the adoption of community-based water purification technologies and demonstrate the relevance of the RANAS factors [17, 19] in explaining adoption, while suggesting that the significance of individual factor groups is context-dependent (see table 1). At the same time, with only four studies that have examined a comparably broad range of psychological determinants (see table 1 [20–23]), the evidence remains limited. Moreover, none of these studies investigated contextual factors and only one of them focused on water purification technologies targeting waterborne diseases. Moreover, all studies were based in East Africa, with similar research in rural India lacking. However, such context specific research is required to establish prioritized targets for local interventions.

What is more, Contzen *et al* [12] identified a major shortcoming of the RANAS model [17, 19] that extends to the literature on the adoption of water purification technologies (including research

Table 1. Overview on the psychological determinants of the adoption of community-based water purification technologies identified in previous research applying or being in line with the RANAS model [17].

Studied outcome	Country	Targeted health issue	RANAS study	Risk factors	Attitude factors	Norm factors	Ability factors	Self-regulation factors
Use of community filter [21]	Ethiopia	Fluorosis	Yes	✓	✓	✗	✗	✓
Use of community filter [22]	Ethiopia	Fluorosis	Yes	✓	✓	✗	✓	✗
Willingness to pay for community filter [20].	Tanzania	Fluorosis	Yes	✓	✓	✗	✗	✗
Regular use of safe water kiosk [23]	Kenya	Waterborne diseases	No	Not considered	✓	✓	✓	✓

Note. ✓ = Psychological determinants from this factor group significantly explained adoption. ✗= None of the psychological determinants from this factor group significantly explained adoption.

on household technologies), given that much of the research examining a comparably broad range of psychological determinants and contextual factors has relied on this model (see [12]). Specifically, the RANAS model is mostly based on research on health behavior change—rather than technology use—in the Global North. Consequently, determinants (and change techniques) that are specific to technology use, and to WaSH technologies in the Global South in particular, such as perceived risks of using purification technologies [24, 25] or trust in relevant actors [24, 25], might be missing.

To address this shortcoming, Contzen *et al* [12] developed the user-focused ToC for decentralized treatment technologies. It summarizes the psychological determinants of the adoption of decentralized water treatment technologies, as identified in recent literature on behavior change and technology adoption. They are clustered into ten groups of determinants with corresponding change techniques ([12]; see figure 1). While the ToC focuses on *psychological* determinants of technology adoption, as they explain why a certain change technique is expected to result in adoption, it also considers *contextual* factors in two ways: first, as potential antecedents of the psychological determinants (e.g. economically poor households may feel less able to use expensive technologies), and second, as potential moderators of the pathways of change (e.g. complex medical information may be more effective for highly educated individuals than for illiterate individuals).

However, also the ToC by Contzen *et al* [12] has a shortcoming: like most of the literature on decentralized treatment technologies (including research on water purification technologies), it focuses on direct associations between psychological determinants and technology use (for exceptions, see [23, 26]), which may overlook important pathways. As Contzen *et al* [12] point out, examining such indirect associations could help identify additional promising intervention targets. For example, if trust in relevant actors is found to be associated with adoption via perceived benefits, interventions might profit from targeting trust instead of perceived benefits directly.

Nevertheless, the ToC by Contzen *et al* [12] can serve as a useful framework for guiding interventions aimed at promoting the adoption of community-based water purification technologies in rural India, particularly when extended to include indirect associations. Accordingly, in this study, we aim to identify, based on the ToC, the psychological determinants and contextual factors that directly and/or indirectly explain adoption in this context. Thereby we address the research gaps outlined above. Specifically, this study responds to the still limited empirical evidence base on psychological determinants of the adoption of community-based water purification technologies, particularly those targeting waterborne diseases, and extends existing research beyond the East African context. It is, to our knowledge, the first study to incorporate contextual factors alongside a broad range of psychological determinants in this research area, and only the second to examine indirect pathways between determinants and adoption, thereby providing a more comprehensive understanding of technology adoption processes.

2. The present study

This study focuses on the adoption of a specific community-based water purification technology, Jivamritam[5] [27]. Jivamritam has been implemented in rural India since 2017. The implementation of Jivamritam is organized as a public-private partnership involving the communities where the technology has been implemented, a local university as the implementing agency, a non-governmental organization which acts as the primary sponsor, and the respective local government, which provides support in securing necessary approvals, for example, from regional authorities. Since its introduction, Jivamritam has been deployed in 300 rural communities [27]. However, adoption has not been consistent across all these communities. In some instances, it was initially adopted but later abandoned. In other cases, it has only been partially adopted, with communities using Jivamritam sporadically. Accordingly, we were interested in the psychological determinants and contextual factors explaining the adoption of Jivamritam as a regular source of drinking water.

Building on the ToC by Contzen *et al* [12] and incorporating qualitative insights from field visits to the rural communities where Jivamritam has been deployed, we selected those psychological determinants and contextual factors which seemed most relevant in the specific context. Table 2 presents the selected psychological determinants, along with information on whether the specific psychological determinant reflects an extension of the RANAS model, as well as the selected contextual factors. Furthermore, for each psychological determinant and contextual factor the anticipated direction of the association with adoption is outlined, supported by prior literature consistent with this expectation.

[5] 'Jivamritam' refers to both the technology and the community-based water purification program. In this paper, it denotes the technology.

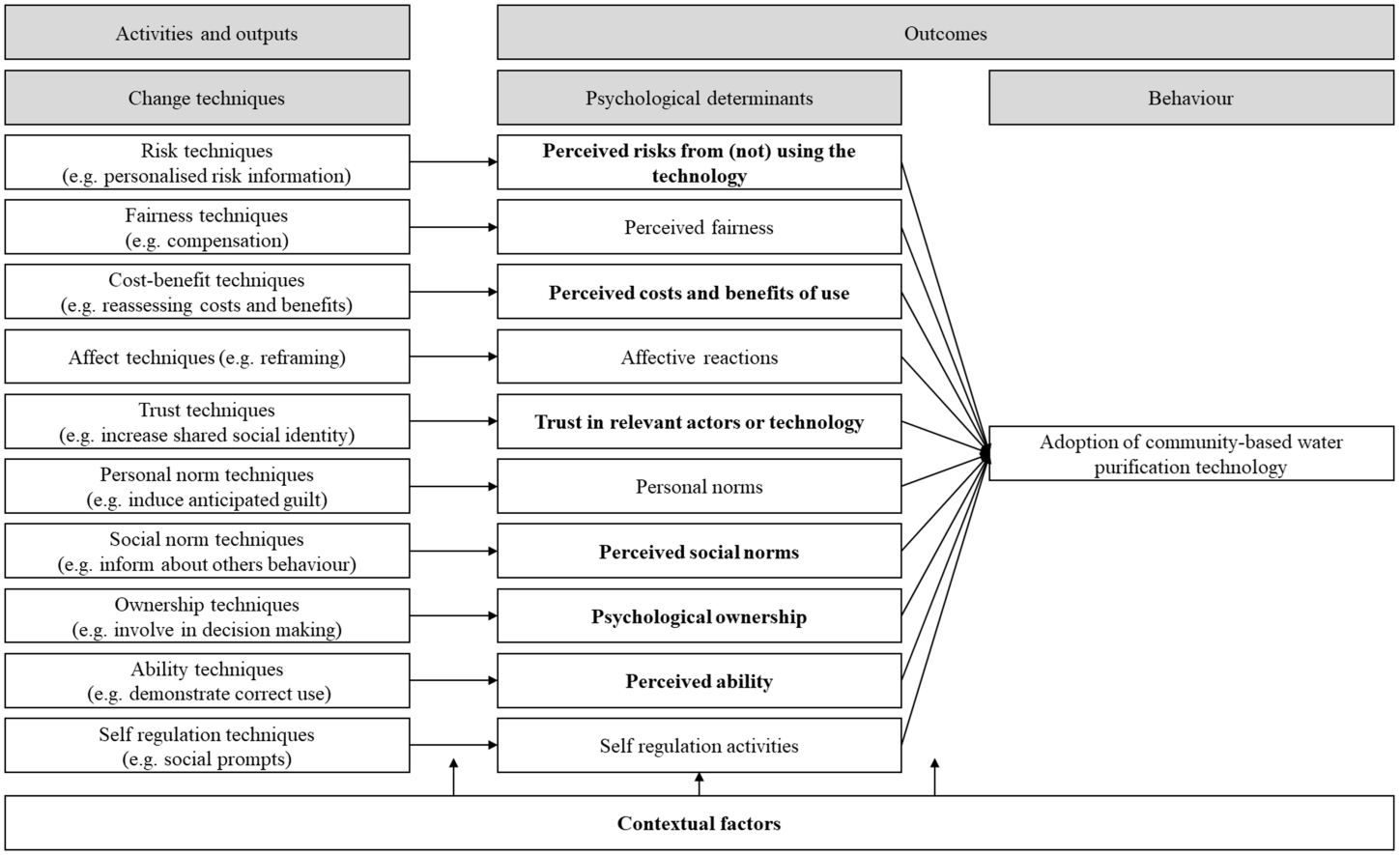


Figure 1. ToC depicting the potential pathways to the adoption of community-based water purification technologies. *Note.* The determinants and factors investigated in the present study are highlighted in bold. Figure adapted with permission from Contzen *et al* [12].

Table 2. Overview of the selected psychological determinants and contextual factors.

Type of determinant/factor	Specific determinant	Extension of RANAS model	Association with adoption	
			Expected direction	Supporting literature
Psychological determinant				
Perceived risks from (not) using the technology	Perceived vulnerability to water-borne diseases		Positive	Adoption of community-based WPT[a] [20–22]
	Perceived severity of water-borne diseases		Positive	
	Perceived risks of using Jivamritam	Yes	Negative	Acceptance of alternative water sources [24] and wastewater reuse [25]
Perceived costs and benefits of use	Perceived good taste of Jivamritam water		Positive	Adoption of community-based WPT[1] [20–23]
	Perceived ease of access of Jivamritam		Positive	
	Perceived cost-effectiveness of using Jivamritam		Positive	
	Perceived time efficiency of using Jivamritam		Positive	
Trust in relevant actors	Trust in the implementing agency, i.e. Amrita Vishwa Vidyapeetham	Yes	Positive	Acceptance of alternative water sources [24] and wastewater reuse [25]
	Trust in the local water committee	Yes	Positive	
Perceived social norms	Perceived descriptive norms (i.e. believing that many others use Jivamritam)		Positive	Adoption of community-based WPT[1] [23]
	Perceived injunctive norms (i.e. believing that others expect them to use Jivamritam)		Positive	
Psychological ownership	Feeling ownership toward Jivamritam	Yes	Positive	Adoption of community-based WPT[1] [13, 23]
Perceived ability	Self-efficacy (i.e. belief in one's capabilities to use Jivamritam)		Positive	Adoption of community-based WPT[1] [22, 23]
Contextual factor				
Geographical distance	Distance of a household from Jivamritam	n.a.	Negative	Households' choice of water source [29]
Assistance from family members	Assistance from family members in water collection	n.a.	Positive	Social support in health behavior change [30]

Note. [a] WPT = water purification technology.

Whenever possible, we provide literature on the adoption of community-based water purification technologies. When such literature is not available, we build on the literature on technology adoption in general, technology acceptance, and behavior change. In sum, all psychological determinants and contextual factors were expected to be positively associated with having adopted Jivamritam as a regular source of drinking water, with two exceptions: perceived risks of using the technology and distance of a household from Jivamritam, which were expected to be negatively associated with adoption.

Following the recommendations of Contzen *et al* [12], we conceptualize for some of the considered psychological determinants and all contextual factors also indirect associations with the adoption of Jivamritam as a regular source of drinking water. These are introduced in the following.

2.1. Conceptualization of indirect associations with adoption of Jivamritam

For two of the psychological determinants selected—namely trust in relevant actors and psychological ownership—we assume, based on the literature, that they are not only directly but also indirectly associated with the adoption of Jivamritam. In the case of trust, we follow research on technology acceptance in general (for a recent review, see [28]). This research indicates that trust in relevant actors regulating a technology is associated with lower perceived costs and risks of the technology as well as higher perceived benefits—probably because trust serves as a heuristic—resulting in higher acceptance (for a study testing the association between trust, risk perception, and acceptance of wastewater reuse, see [25]).

Therefore, we expect that the more people trust in the implementing agency—Amrita Vishwa Vidyapeetham—and the local water committee, the less risks and the more benefits they perceive of using Jivamritam, and therefore, the more likely they are to have adopted Jivamritam as a regular source of drinking water (see figure 2).

In the case of psychological ownership, we follow research on the use of safe water kiosks by Contzen and Marks [23], which found that psychological ownership was associated with several of the psychological determinants considered here, which in turn explained kiosk use. First, stronger psychological ownership was associated with higher perceived benefits related to kiosk usage, likely because a psychologically owned good may be viewed as an extension of the self and therefore positive [31]. Next—and likely because community-based ownership of the kiosk may have created an environment of mutually expected use with each co-owner being expected and expecting others to use their shared property [23]—stronger psychological ownership was associated with stronger perceived social norms for using the kiosk. Finally, stronger psychological ownership was associated with higher self-efficacy beliefs related to kiosk usage, likely because feeling ownership may increase efforts related to the owned good [32], which may result in more mastery experience [33]. Therefore, we expected that the more people feel ownership toward Jivamritam, the more benefits they perceive of using Jivamritam, the stronger the perceived social norms related to adopting Jivamritam, and the higher the self-efficacy related to using Jivamritam, and in turn, the more likely they are to have adopted Jivamritam as a regular source of drinking water (see figure 2).

For the two contextual factors considered—namely, the geographical distance of a household from Jivamritam and assistance from family members in water collection—no previous research on indirect associations with adoption is available. Nevertheless, we expect households located closer to Jivamritam, as well as those receiving more help from family members in fetching water, to perceive greater ease of access, and in turn, to be more likely to have adopted Jivamritam as a regular source of drinking water (see figure 2).

3. Methods

3.1 Study sites

To investigate the psychological determinants and contextual factors of the adoption of Jivamritam in rural India, we conducted a cross-sectional, correlational study in rural communities in the states of Kerala, Karnataka, Andhra Pradesh, Odisha, Uttar Pradesh, and Himachal Pradesh, in which Jivamritam has been implemented. The vast majority of installations occurred in Kerala (see table 3), where the technology originated.

As a first step, the 300 rural Indian communities where Jivamritam has been implemented were assessed for water quality using data from the Ministry of Drinking Water and Sanitation, Government of India [34]. Specifically, location-specific water quality parameters extracted from this dataset were compared against standards by the Bureau of Indian standards [35] to identify cases with significant contamination [34]. The severity of contamination was subsequently validated through field visits and

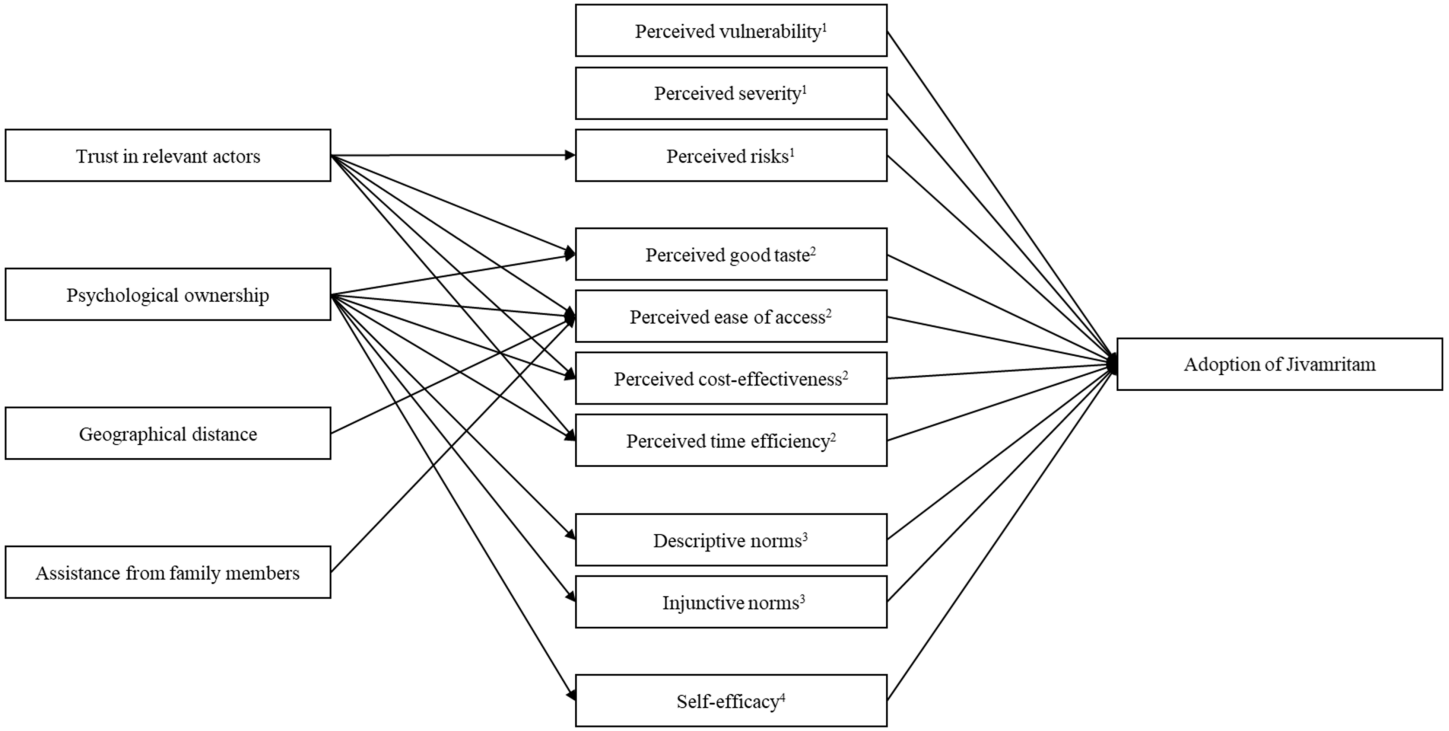


Figure 2. Depiction of the conceptualized direct and indirect associations with adoption of Jivamritam. *Note.* For indirect determinants, only mediated pathways to adoption are shown; direct paths are not displayed for reasons of clarity. [1] Determinants belong to the group 'Perceived risks from (not) using the technology'. [2] Determinants belong to the group 'Perceived costs and benefits of use'. [3] Determinants belong to the group 'Perceived social norms'. [4] Determinant belongs to the group 'Perceived ability'.

Table 3. Distribution of Jivamritam communities by inclusion status and state.

Subset of communities	Total	State	
		Kerala	Other state[a]
Communities with Jivamritam	300	275 (91.7%)	25 (8.3%)
Selected for data collection	54	48 (88.9%)	6 (11.1%)
Excluded after data collection	14	13 (92.9%)	1 (7.1%)
Included in final analysis	40	35 (87.5%)	5 (12.5%)

Note. [a] The other states being Karnataka, Andhra Pradesh, Odisha, Uttar Pradesh and Himachal Pradesh.

informal discussions with local community leaders, resulting in a shortlist of 75 communities with substantial water contamination issues. Of these, 64 communities expressed willingness to participate in the study, of which 54 communities were ultimately selected for data collection. The vast majority of these communities were located in Kerala, approximately reflecting the overall distribution of Jivamritam in Kerala and in the other participating states (see table 3). The selected communities, including those in Kerala, were purposefully chosen as they cover diverse cultural and geographical backgrounds, including variations in topography, climate and livelihoods [36]. In each community, permission to collect data was granted by the president of the local government.

During data analysis, data from 14 communities where Jivamritam was no longer operational at the time of data collection had to be excluded, as the main outcome variable of this study was whether a household had adopted Jivamritam as a regular source of drinking water and adoption was no longer possible in these communities. Accordingly, the present study is based on data from 40 communities, the vast majority of which are again located in Kerala, with one community each from the other participating states (see table 3).

3.2. Sampling procedure and sample

Data were collected between 1 July 2023 and 15 August 2023. Participating households were selected through random route sampling [37]. Specifically, each community was divided into five zones to which enumerators were randomly assigned. Within each zone, one house was randomly picked as the starting point, from which the enumerators approached every second household while proceeding in a predetermined direction. At each selected household, the enumerators inquired whether the individual responsible for water collection in a household was willing to participate. If a household was non-eligible, refused to participate, or if nobody was at home, the next household along the route was approached.

All participants were adults. Participation was voluntary and based on informed consent, which included information on anonymized handling of all data. Consent was given either in written form or, due to high illiteracy in some communities, in verbal form. Verbal consent was documented by the enumerators prior to the interview, in accordance with the approved study protocol. No incentive was provided. Ethical clearance for this study was obtained from the institutional human ethics committee (IHEC), Amrita Vishwa Vidyapeetham (Ref. No. IHEC/2023/10/01).

Across the 40 communities included in the present study, 760 eligible households were approached of which 671 agreed to participate (response rate of 88%), which were all included in the analysis. While we had intended to collect data from 25 households per community, the final cluster sizes ranged from four to 40 participants with an average cluster size of 17 (see SM-1 in the supplementary material).

Of the respondents, 68% were women and their age ranged from 19 to 76 years ($M = 48.39$, $SD = 8.46$). As to educational attainment, 4% had no formal education, 26% had completed primary education, 66% had finished secondary education, and 4% had obtained a university degree or another higher qualification. Of the participating households, 89% were below the poverty line, defined in rural India as households with a per capita consumption expenditure below INR 816 per month [38].

3.3. Data collection approach

Data were collected through structured face-to-face interviews conducted in the participant's mother tongue, at their home. Each interview lasted approximately 45 min and involved a team of four with a clear division of roles to minimize potential social desirability bias. The first author and a university staff member acted as enumerators and jointly interviewed the participants and entered the data. A member of the Jivamritam implementation team joined the interviews as a technical expert and answered specific questions about the technology, if requested by the participant, yet without being involved in interviewing and data recording. A local village coordinator facilitated introductions and helped establish rapport

with participants, again without being involved in interviewing and data recording. All data collectors were trained in interviewing techniques. Data were entered using the mobile application empower app[6] [39].

3.4. Questionnaire and measures

The interviews were based on a structured questionnaire, which included questions on demographics, used drinking water sources, and psychological determinants of the adoption of Jivamritam. The questions, drafted in English, were revised in a collaborative review session with ten members of the Jivamritam implementation team and five experts specialized in water purification technology and community-based infrastructure. The revised questionnaire was translated into the five local languages spoken across the participating communities—Malayalam, Hindi, Kannada, Telugu, and Odia—and back-translated into English. Discrepancies between the original and the back-translated questionnaire were discussed and resolved by the first author and members of the Jivamritam implementation team. The questionnaire was pretested with 15 respondents from communities in which Jivamritam had been implemented and revised to increase the comprehensibility of a few questions.

To keep the interview as brief as possible and minimize participants' cognitive burden and survey fatigue, we followed previous research in the WaSH sector [23, 40] and the C-OAR-SE method [41]. This method states that the single most important criterion for item design is maximal content validity, which can be achieved for basic, unidimensional constructs using single-item measures. Accordingly, all unidimensional constructs were measured with single-item measures designed to maximize content validity, whereas the only multi-dimensional construct included in our study, namely collective psychological ownership, was measured with a multi-item measure. The subsequent paragraphs provide detailed descriptions of the measures employed in this study.

3.4.1. Adoption of Jivamritam as regular source of drinking water

The outcome variable, adoption of Jivamritam, was assessed with the question, 'Do you regularly use water from Jivamritam in your community?' with the response options: 1 = *'Yes'* and 0 = *'No'*.

3.4.2. Psychological determinants of the adoption of Jivamritam

Table 4 presents the items used to measure the psychological determinants of the adoption of Jivamritam, including each item's wording and response scale as well as their means and standard deviations. Most of the items used to assess the psychological determinants of the adoption of Jivamritam were adapted from studies applying the RANAS model [17, 19]. The original study serving as the source for each item is listed in table 4. For three determinants—perceived risks of using the technology, trust in relevant actors and psychological ownership—which are not considered in the RANAS approach, we adapted items from other literature (see table 4). Psychological ownership, as a multi-dimensional construct, was assessed with three items, each representing one dimension of psychological ownership, namely personal, household, and community ownership. As the three items formed an internally consistent scale (Cronbach's $\alpha = 0.95$), the responses were averaged to a composite scale (for the mean and standard deviation of the composite scale, see table 4). All items applied a 5-point Likert-type scale.

3.4.3. Contextual factors

Distance from Jivamritam. Respondents reported the geographical distance of their household from Jivamritam using the following response options: 1 = *'0–50 meters'*; 2 = *'50–100 meters'*; 3 = *'100–150 meters'*; 4 = *'150–200 meters'* and 5 = *'⩾ 200 meters'*. The responses were later recoded to 0 = *'0–100 meters'* and 1 = *'more than 100 meters'*.

Assistance from family members. To determine the assistance provided by family members in water collection, we used the question 'How many of your family members help you in collecting water?' with the response options ranging from 0 to 4 family members. The responses were later recoded to 0 = *'no family members assisting'* and 1 = *'at least one family member assisting'*.

3.5. Data analysis procedure

All analyses were done in R version 4.2.3 [43]. Prior to fitting the analytical models, we checked for unengaged responses (straight lining) by calculating within-participant response variance. We evaluated the presence of influential cases using Cook's distance [44] and standardized DFBetas [45]. To assess the

[6] https://play.google.com/store/apps/details?id = edu.amrita.empower&hl = en-US

Table 4. Items used to measure the psychological determinants.

ToC determinant group	Psychological determinant	Item wording and response scale	Item adapted from:	*M*	*SD*
Perceived risks of (not) using the technology	Perceived vulnerability	How high is the risk that you will fall sick if you drink untreated water from other sources? (1 = *No risk at all* to 5 = *Very high risk*)	[17]	3.75	1.06
	Perceived severity	Last time you had diarrhea/water borne disease, how severe was the impact on your daily life? (1 = *Not severe at all* to 5 = *Very severe*)	[17]	2.91	0.81
	Perceived risks of using the technology	How safe is the water provided by Jivamritam? (1 = *Very safe* to 5 = *Not safe at all*)	[24]	2.08	0.91
Perceived costs and benefits	Perceived good taste	How much do you like the taste of water from Jivamritam? (1 = *Do not like at* all to 5 = *Like very much*)	[42]	3.83	1.02
	Perceived ease of access	How effortful is it to access Jivamritam from your house? (1 = *Very difficult* to 5 = *Very easy*)	[42]	3.77	1.10
	Perceived cost-effectiveness	How cost effective is Jivamritam compared to other sources? (1 = *Not cost effective at all* to 5 = *Very cost effective*)	[42]	3.89	1.09
	Perceived time efficiency	How much time do you spend in using Jivamritam? (1 = *Quite a lot of time* to 5 = *Hardly any time*)	[42]	3.70	1.12
Trust in relevant actors	Trust in the implementing agency	Do you trust the implementing agency, Amrita? (1 = *No trust at all* to 5 = *Very high trust*)	[25]	3.95	0.95
	Trust in the water committee	How much trust do you have in the water committee with respect to governing and maintaining Jivamritam? (1 = *No trust at all* to 5 = *Very high trust*)	[25]	3.68	1.00
Perceived social norms	Perceived descriptive norms	What percentage of people in your community use Jivamritam? (1 = 0%–20% to 5 = 80–100%)	[17]	1.87	1.37
	Perceived injunctive norms	People who are important to you, how much do they approve of using Jivamritam? (1 = *Do not approve at all* to 5 = *Strongly approve*)	[17]	3.74	0.98
Psychological ownership	Personal	How much do you feel that you are one of the owners of Jivamritam? (1 = *Not at all* to 5 = *Very much*)	[23]	3.62	1.12
	Household	How much do you feel that your household is one of the owners of Jivamritam? (1 = *Not at all* to 5 = *Very much*)			
	Community	How much do you feel that your community is one of the owners of Jivamritam? (1 = *Not at all* to 5 = *Very much*)			
Perceived ability	Perceived self-efficacy	How certain are you that you will always be able to use water from Jivamritam? (1 = *Not certain at all to* 5 = *Very certain*)	[17]	3.69	1.17

risk of multicollinearity among the predictors, we computed variance inflation factors (VIF) and tolerance statistics [46]. Because the psychological determinants were uniformly measured on a 1–5 scale, they were not standardized prior to analysis.

3.5.1. Test of direct associations with Jivamritam adoption

Since the outcome variable—adoption of Jivamritam—is binary and respondents' data were clustered within communities, a mixed-effects logistic regression model using the generalized linear mixed model (GLMM) framework [47] was employed to identify the psychological determinants and contextual factors associated with the adoption of Jivamritam. GLMMs extend generalized linear models by incorporating both fixed and random effects, thereby modeling variability at both the individual and group levels [48]. In our case, all psychological determinants and contextual factors represented fixed effects, and the respondents' community represented a random effect. We utilized the glmer function from the lme4 package [49] to fit the GLMMs, specifying a binomial family for the outcome variable. The model was fitted using the maximum likelihood estimation and optimized using the BOBYQA optimizer to enhance convergence [50]. As is standard for logistic regression models, odds ratios (*ORs*) are reported as effect sizes [51], representing how the odds of the outcome differ between one group and another [52]. Bootstrapping with 2,000 resamples was applied to estimate bias-corrected 95% confidence intervals (CIs).

3.5.2. Test of indirect associations with Jivamritam adoption

We ran additional analyses to test potential indirect associations of psychological determinants and contextual factors with adoption of water purification technologies. Specifically, we examined whether trust in relevant actors, psychological ownership, and the two contextual factors tested also indirectly explain the adoption of Jivamritam as outlined in figure 2. To quantify these indirect associations, we followed the basic logic of mediation models [53]. Specifically, the indirect association of an antecedent with the outcome variable via a mediator can be quantified as the product of the association between the antecedent and the mediator (the a path) and the association between the mediator and the outcome (the b path), while the remaining direct association is represented by the c' path (see figure 3(a)). While the b paths were obtained from the GLMM described above, we conducted additional GLMMs to estimate the a paths. To this end, we ran eight additional GLMMs—one for each tested mediator—with each GLMM including a specific set of antecedents. For example, in the GLMM used to test perceived risks of using the technology as a mediator, perceived risks of using the technology was the outcome variable, while trust in the implementing agency and trust in the water committee were the tested antecedents. Subsequently, we calculated the indirect associations by multiplying the coefficients of the respective a and b paths (see figure 3(a)).

To assess the statistical significance of these indirect associations, we used non-parametric bootstrapping with 2000 resamples to generate their distributions. From these distributions, 95% CIs were computed by extracting the 2.5th and 97.5th percentiles [53]. An indirect association was considered statistically significant if its CIs did not include zero.

Moreover, for each tested antecedent assumed to be associated with adoption via multiple mediators (i.e. trust in the implementing agency, trust in the water committee, and psychological ownership), we computed the total indirect association with adoption. We followed the procedure recommended by Hayes [53] which assumes that mediators are independent (i.e. they operate in parallel), which aligns with our conceptual model (see figure 1). Specifically, we extracted the bootstrapped indirect association from each relevant mediator model and summed these associations within each bootstrap iteration to generate a distribution of the total indirect association per antecedent (see figure 3(b)). From this distribution, we calculated the mean total indirect association and its 95% CI using the 2.5th and 97.5th percentiles. For the antecedents assumed to be associated with adoption via a single mediator (i.e. distance from Jivamritam and assistance from family members), the total indirect association is equivalent to the indirect association through the specific mediator. Therefore, no additional computations were indicated.

4. Results

Of the participating households, 464 (69%) reported to have adopted Jivamritam as regular source of drinking water. The point-biserial correlations of psychological determinants, contextual factors and

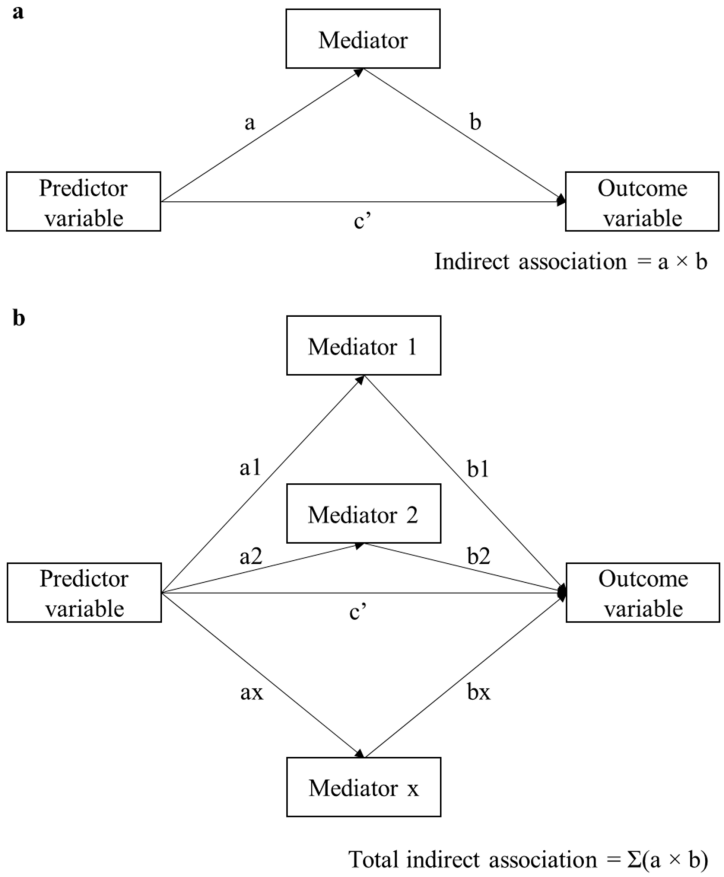


Figure 3. Graphical depiction of applied mediation approach. (a). Depiction of simple mediation model. (b). Depiction of multiple mediation model.

Jivamritam adoption are provided in SM-2 in the supplementary material. All psychological determinants and contextual factors were significantly correlated with the adoption of Jivamritam, with correlations ranging between $r = -.55$ for perceived risks of using the technology and $r = .68$ for perceived good taste.

All regression assumptions were met. No unengaged responses (straight liners) or influential cases were identified (Cook's distance < 1; absolute standardized DFBetas < 1). Furthermore, VIF values ranged from 1.16 to 6.03 and indicated no serious concern regarding multicollinearity. Specifically, all predictors showed VIF values below 5, with one exception: psychological ownership, which slightly exceeded this threshold (VIF = 6.03) but remained well below the commonly accepted threshold of 10.

4.1. Direct associations with adoption of Jivamritam

We first examined the direct associations between the psychological determinants and contextual factors with the adoption of Jivamritam (see table 5). The GLMM yielded an intraclass correlation coefficient of 0.41, indicating that 41% of the total variance in the outcome variable is attributable to differences between communities, with the remaining 59% due to within-community variation. We found that five of the thirteen psychological determinants and one contextual factor were significantly associated with the adoption of Jivamritam. Specifically, the adoption of Jivamritam was more likely when people perceived waterborne diseases as more severe, when ease of access and cost-effectiveness were rated higher, when trust in the implementing agency was greater, and when descriptive norms were stronger. In addition, assistance from family members was also significantly associated with adoption: when such support was received, adoption of Jivamritam was more likely.

4.2. Indirect associations with adoption of Jivamritam

Next, we tested whether trust in relevant actors, psychological ownership and contextual factors were also indirectly associated with adoption of Jivamritam (see table 6). Starting with the contextual factors, assistance from family members in water collection, but not distance from Jivamritam, was indeed indirectly associated with adoption, mediated by perceived ease of access. That is, receiving assistance

Table 5. GLMM testing the direct associations with Jivamritam adoption.

Antecedents	Estimate	*SE*	95% CI	*OR*
Perceived vulnerability	−0.43	0.22	[−0.93, 0.001]	0.65
Perceived severity	0.55*	0.24	[0.05, 1.09]	1.74
Perceived risks of using the technology	−0.45	0.27	[−0.96, 0.32]	0.64
Perceived good taste	−0.49	0.25	[−1.14, 0.003]	0.62
Perceived ease of access	0.80**	0.32	[0.19, 1.58]	2.22
Perceived cost-effectiveness	0.77**	0.30	[0.24, 1.59]	2.17
Perceived time efficiency	−0.42	0.27	[−1.09, 0.10]	0.66
Trust in the implementing agency	0.76*	0.31	[0.12, 1.53]	2.14
Trust in water committee	0.41	0.35	[−0.26, 1.28]	1.50
Perceived descriptive norms	1.03***	0.28	[0.63, 2.01]	2.80
Perceived injunctive norms	0.12	0.35	[−0.62, 0.86]	1.12
Psychological ownership	0.71	0.37	[−0.01, 1.54]	2.04
Self-efficacy	0.31	0.27	[−0.23, 0.91]	1.36
Distance from Jivamritam	0.22	0.37	[−0.53, 1.08]	1.25
Assistance from family members	3.22*	1.32	[1.66, 16.60]	24.96

Note. $N = 671$. Akaike Information Criterion (AIC) = 322.1. Bayesian Information Criterion (BIC) = 398.7. Intraclass Correlation Coefficient (ICC) = 0.41. CI = confidence interval. *OR* = odds ratio. * $p \leqslant .05$. ** $p \leqslant .01$. *** $p \leqslant .001$.

from family members in water collection was associated with a higher likelihood of adoption through a greater perceived ease of access.

In the case of the psychological determinants, on the one hand, trust in both the implementing agency and the water committee as well as psychological ownership were indirectly positively associated with the adoption of Jivamritam, namely through a greater perceived ease of access and higher perceived cost-effectiveness. On the other hand, all three antecedents were also indirectly negatively associated with the adoption of Jivamritam, namely through a higher perceived good taste. These unexpected negative associations stemmed from a negative, though non-significant, association between perceived good taste and adoption in the initial GLMM (see table 5). However, this pattern may reflect a suppression effect [54] rather than a substantive negative association, as the point-biserial correlation between perceived good taste and adoption was positive (see SM-2 in the supplementary material). Such sign reversals can occur when a predictor, here perceived good taste, shares substantial variance with other, stronger antecedents included in the model, such as perceived ease of access, cost-effectiveness and time efficiency (see SM-2 in the supplementary material). When these variables are included concurrently, overlapping variance may alter (e.g. reverse) the regression coefficient of weaker predictors [54].

Taken together, the positive indirect associations and the unexpected negative indirect association—potentially resulting from a suppression effect—of the three antecedents, tended overall to form a positive indirect association with adoption (see table 7). However, this total indirect association was significant only in the case of trust in the local water committee, suggesting that greater trust in the committee was associated with a higher likelihood of adoption through increased perceived ease of access and higher perceived cost-effectiveness.

5. Discussion

This study identified the psychological determinants and contextual factors that directly and/or indirectly explain the adoption of a community-based water purification technology deployed in rural India, Jivamritam [27]. Following the user-focused ToC proposed by Contzen *et al* [12], the insights gained can guide interventions aimed at promoting the adoption of Jivamritam across communities.

Of the thirteen psychological determinants considered, five directly explained adoption. First, perceived severity of waterborne diseases was significantly and positively associated with adoption. Similarly, perceived health risks associated with consuming untreated water have been identified in prior research as important drivers of adoption of community-based water purification technologies [20]. Next, consistent with previous research on adoption of community-based water purification technologies [20–23], higher perceived benefits—specifically, greater perceived ease of technology access and higher perceived cost-effectiveness—were significantly associated with a higher likelihood of adoption. Moreover, adoption was also significantly explained by perceived, descriptive norms: the more community members were perceived to have adopted Jivamritam, the higher the likelihood of adoption. This finding is consistent

Table 6. Mediation analysis testing the indirect associations with Jivamritam adoption.

		a path		*b* path[1]						
Mediator	Indirect antecedents	Estimate	*SE*	Estimate	SE	Indirect association	Bootstrap 95% CI	*OR*	AIC	BIC
Perceived risks of using the technology	Trust in the implementing agency	−1.17***	0.15	−0.45	0.27	0.53	[−0.12, 1.76]	0.31	1147.46	1179.02
	Trust in water committee	−1.15***	0.15			0.52	[−0.13, 1.69]	0.32		
Perceived good taste	Trust in the implementing agency	0.75***	0.14	−0.49	0.25	−0.37	[−1.06, −0.03]	2.11	1295.06	1337.62
	Trust in water committee	0.78***	0.17			−0.38	[−1.19, −0.02]	2.19		
	Psychological ownership	0.85***	0.15			−0.42	[−1.26, −0.02]	2.34		
Perceived ease of access	Trust in the implementing agency	0.48**	0.15	0.80**	0.32	0.38	[0.07, 1.17]	1.62	1024.11	1069.18
	Trust in the water committee	0.95***	0.18			0.76	[0.21, 1.95]	2.58		
	Psychological ownership	1.57***	0.18			1.26	[0.29, 2.86]	4.82		
	Distance from Jivamritam	0.23	0.20			0.18	[−0.17, 0.76]	1.25		
	Assistance from family members	1.56**	0.47			1.25	[0.14, 3.15]	4.77		
Perceived cost-effectiveness	Trust in the implementing agency	0.90***	0.15	0.77**	0.30	0.69	[0.28, 1.96]	2.47	1127.71	1163.78
	Trust in the water committee	1.12***	0.18			0.86	[0.30, 2.48]	3.05		
	Psychological ownership	1.18***	0.16			0.91	[0.34, 2.55]	3.24		
Perceived time efficiency	Trust in the implementing agency	0.79***	0.15	−0.42	0.27	−0.33	[−1.14, 0.17]	2.21	1141.45	1177.51
	Trust in the water committee	0.44*	0.18			−0.18	[−0.81, 0.10]	1.55		
	Psychological ownership	1.74***	0.17			−0.73	[−2.57, 0.31]	5.69		
Perceived descriptive norms	Psychological ownership	0.04	0.16	1.03***	0.28	0.04	[−0.71, 0.52]	1.04	942.48	969.52
Perceived injunctive norms	Psychological ownership	2.28	0.14	0.12	0.35	0.27	[−2.08, 2.83]	9.79	1114.80	1141.84
Self-efficacy	Psychological ownership	2.58	0.14	0.31	0.27	0.80	[−1.09, 2.88]	13.26	1198.81	1225.84

Note. $N = 671$. [1] The b paths represent the associations between the respective mediator and the outcome; the corresponding estimates and SEs are identical with those reported in table 4. CI = confidence interval. *OR* = odds ratio. AIC = Akaike Information Criterion. BIC = Bayesian Information Criterion. * $p \leqslant .05$. ** $p \leqslant .01$. *** $p \leqslant .001$.

Table 7. Total indirect association of the tested psychological determinants with the adoption of Jivamritam.

		95% CI	
Antecedent	Total indirect effect	LL	UL
Trust in the implementing agency	0.90	−0.27	2.91
Trust in water committee	1.58	0.38	4.04
Psychological ownership	2.13	−1.48	6.42

Note. CI = confidence interval. LL = lower limit. UL = upper limit.

with research on safe water kiosks by Contzen and Marks [23], although their study tested social norms by combining measures of descriptive and injunctive norms. Finally, greater trust in the implementing agency was found to be associated with higher adoption, which parallels initial findings on the acceptance of alternative water sources and wastewater reuse [24, 25]. In sum, psychological determinants covering four of the six determinant groups we had considered from the user-focused ToC [12] were found to be directly associated with adoption—namely (1) perceived risks from (not) using the technology, (2) perceived costs and benefits of use, (3) trust in relevant actors, and (4) perceived social norms. The remaining two groups—psychological ownership and perceived ability (represented by self-efficacy)—did not significantly explain adoption, at least when focusing on direct associations.

Of the two contextual factors we considered—the geographical distance of a household from Jivamritam and assistance from family members in water collection—only the latter significantly explained adoption. Specifically, when assistance from family members was present, households were more likely to have adopted Jivamritam, which parallels research on social support in health behavior change [30].

As to the indirect antecedents of adoption, we found a significant total indirect association for trust in local water committees, mediated through perceived ease of access and cost-effectiveness. As the tested direct association was non-significant when controlled for all other predictors, the effect is fully mediated by perceived benefits, underscoring the importance of also examining indirect antecedents to gain a comprehensive understanding of the factors underlying adoption (see [12]). While we found some positive indirect associations for trust in the implementing agency and for psychological ownership, the total indirect associations with adoption were not significant. Taken together, our findings on the indirect psychological antecedents are partly in line with research on technology acceptance (e.g [28].) and ownership toward safe water kiosks [23].

In addition, assistance from family members, but not distance from Jivamritam, was indirectly associated with adoption, mediated by perceived ease of access. That is, receiving assistance in water collection was associated with higher likelihood of adoption through greater perceived ease of access. To our knowledge, this is the first study testing this indirect association.

5.1. Practical implications

It is widely accepted that behavioral interventions are most effective when grounded in theory and evidence on how change happens [12, 17, 18]. Accordingly, the insights gained on psychological determinants and contextual factors explaining the adoption of Jivamritam may provide practical guidance for project managers and policymakers in the WaSH sector to design targeted interventions aimed at promoting the adoption of community-based water purification technologies. Specifically, the user-focused ToC by Contzen *et al* [12] can be consulted to guide the selection of change techniques assumed to target the identified psychological determinants.

To start with, this selection could be based on the identified direct associations with adoption. For example, to promote perceived severity of waterborne disease, interventions could potentially profit from applying risk techniques that highlight not only the severity of direct health consequences for groups at higher risk (i.e. children under the age of five), but also livelihood losses due to illness among adults. Key benefits like ease of access and cost-effectiveness of Jivamritam could be promoted through cost-benefit techniques that communicate, for example, how Jivamritam outperforms other water sources on these dimensions. With social norm techniques, such as public signaling through asking households that have adopted Jivamritam to display a flag in front of their house, community members' adoption could be made more visible, thereby strengthening descriptive norms. To promote trust in the implementing agency, trust techniques that emphasize, for example, the integrity of this actor, could be used, such as regular and transparent reporting on maintenance activities and water quality at the water infrastructure.

In addition, the identified indirect associations with adoption provide further entry points for interventions. Specifically, applying further trust techniques that target trust in the water committee could also be promising. For example, shared identity could be fostered through participatory mechanisms such as town hall meetings, in which community members and committee representatives jointly discuss and resolve local issues related to Jivamritam.

Finally, the finding that receiving assistance from family members in water collection was both directly and indirectly associated with adoption highlights the potential of targeting social support in interventions (see [30]). Importantly, rather than focusing solely on the individual primarily responsible for water collection, interventions could engage all family members to foster such assistance. For example, households could be invited to plan support provision by identifying days or times of the day on which assistance is particularly needed. In addition, those primarily responsible for water collection could be empowered to actively seek support from other household members, for example by strengthening communication and coordination skills.

5.2. Strengths, limitations, and perspectives for future research

To our knowledge, this is the first comprehensive study to examine a broad range of psychological determinants and contextual factors as antecedents of the adoption of community-based water purification technologies beyond East Africa, specifically in rural India, while previous research in this context has typically addressed only individual or a few such antecedents. Moreover, this is one of the first papers to consider collective psychological ownership in the context of community-based water purification technologies (for an exception, see [23]) and the first one to investigate trust in relevant actors in this context. The finding that trust in the water committee is indirectly associated with adoption, while trust in the implementing agency is directly associated, underscores the importance of considering these determinants.

Next, the present study is one of only a few to test and confirm indirect associations of psychological determinants and contextual factors with adoption of water purification technologies (for other such studies, see [23, 26]). Identifying such indirect associations is not only relevant from a theoretical point of view; it also provides further entry points for targeted interventions. By addressing both direct and indirect antecedents, the effectiveness of interventions could potentially be enhanced. Future research could explore this further by testing whether targeting indirect antecedents as well can increase intervention effectiveness.

Nonetheless, our study is not exempt from limitations. First, the sample focused primarily on communities from the state of Kerala, as this is where the studied technology originated and was predominantly deployed. While this limits geographic scope, the included communities vary considerably in socio-economic, cultural and geographical characteristics, adding valuable diversity to the analysis. Nevertheless, the focus on Jivamritam and thus on communities in Kerala limits the generalizability of the findings to other rural contexts in India. Therefore, future research should expand more intensively to other Indian states, for example, by investigating additional community-based water purification technologies, which would also provide the opportunity to compare psychological determinants and contextual factors across technologies.

Next, to keep the interview as brief as possible and minimize participants' cognitive burden and survey fatigue, we relied primarily on single-item measures to assess the psychological determinants, the context factors and the outcome (i.e. Jivamritam adoption). While this approach is consistent with previous research in the WaSH sector [23, 40] and the C-OAR-SE method [41], it precludes the assessment of internal consistency. Future research should, where feasible, employ multi-item measures for all constructs.

Moreover, due to the cross-sectional, correlational nature of our data, we cannot infer causality. Future research could employ randomized controlled trials to test whether and how targeted interventions change specific psychological determinants and, in turn, technology adoption. Additionally, longitudinal studies could track changes in psychological determinants and adoption over time, enabling also the examination of potential feedback loops between adoption and these determinants.

Finally, the presence of a member of the Jivamritam implementation team and a local village coordinator during the interviews may have introduced some degree of social desirability bias. Future research should ensure that interviews are conducted solely in the presence of neutral, independent facilitators, with no direct affiliation with the water purification technology or local leadership, to minimize response bias and encourage more candid participant reporting.

6. Conclusion

As one of the first studies to comprehensively assess the psychological determinants and contextual factors that explain the adoption of a community-based water purification technology outside East Africa, specifically in rural India, our research provides important insights for policy and practice. Importantly, our results suggest that successful technology deployment requires going beyond infrastructure provision to behaviorally informed intervention strategies that target the identified psychological determinants and contextual factors. As a starting point, the psychological determinants and contextual factors identified to directly explain adoption could be targeted. The finding that such variables as perceived descriptive norms, trust in the implementing agency, and assistance from family members explained adoption, emphasizes the need of interventions to go well beyond the provision of risk information, by also incorporating norm and trust techniques, as well as approaches that strengthen social support. Moreover, our findings suggest that in addition to the psychological determinants and contextual factors identified to directly explain adoption, attention should also be paid to distal variables that indirectly explain adoption. Specifically, trust in water committees, as a distal variable, could be a promising target for interventions and could be targeted, for example, through participatory mechanisms that strengthen a sense of shared identity. Future research should continue to investigate these psychological determinants and contextual factors in diverse socio-cultural contexts to refine strategies for improving the adoption of such technologies, as well as to rigorously test the effectiveness of these strategies in practice.

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Data availability statement

The data that support the findings of this study are openly available at the following DOI: https://doi.org/10.17632/7tc2zf72yf.1 [55].

Supplementary Material available at https://doi.org/10.1088/2515-7620/ae7b01/data1.

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Conflict of interest

The authors declare that they have no competing interests.

Ethics approval and consent to participate

Ethical clearance for this study was obtained from the Institutional Human Ethics Committee (IHEC), Amrita Vishwa Vidyapeetham (Ref. No. IHEC/2023/10/01) in accordance with the Declaration of Helsinki [56]. All participants were adults (⩾18 years) who participated voluntarily. Informed consent was obtained from all participants; this was provided in written form or, due to limited literacy in specific communities, via oral consent. The use of oral consent for these participants was explicitly approved by the IHEC. Oral consent was witnessed and documented by the enumerators prior to the interview in accordance with the approved study protocol. No incentives were provided for participation. Administrative permission for data collection was granted by the President of the local government

in each community. All data were anonymized prior to analysis to protect participant privacy, and the study was assessed to pose no risk to individual participants.

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