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Continuation of Health Behaviors: Psychosocial Factors Sustaining Drinking Water Chlorination in a Longitudinal Study from Chad

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Abstract: Behavior that has changed following promotion campaigns is usually not maintained at its initial level. Psychosocial factors for initiating behavior are often not the same as for the continuation of health behaviors such as water treatment and are much less understood. Better knowledge of factors for behavioral continuation would help to improve programs, both in the design of strategies for sustainable behavior change and by defining stronger criteria for the evaluation of sustainability. This study compared the mindsets of caregivers who continuously performed household drinking water treatment over time with individuals that stopped doing so in a population sample from Chad. Several factors from health psychology based on the Risks, Attitudes, Norms, Abilities, and Self-Regulation (RANAS) model were used to compare the two groups and examine their differing development. Normative factors such as others' behavior, personal obligation, social support and discourse, perceived self-efficacy convictions, action control, and intention best discriminated between the two groups and developed significantly more positively over time for continuers of water treatment. These factors should be considered when designing future interventions intended to lead to sustainable behavior change.

Keywords: behavior change; health psychology; behavioral continuation; drinking water; WASH

1. Introduction

Globally, an estimated 1.9 billion people either use an unimproved water source or an improved source that is fecally contaminated [1–3]. Despite some progress in attaining the Millennium Development Goals concerning the access to an improved water source, the number of people in rural Africa without provision of safe drinking water has actually grown between 1990 and 2006 from 243 to 272 million [4]. Ideally, any water source should undergo laboratory testing to judge its suitability to provide safe drinking water wherever possible [5]. Limited access to safe drinking water represents a major health risk in many low- and middle-income countries; unsafe drinking water is deemed responsible for over half a million deaths from diarrheal diseases yearly [6]. Among those, cholera is causing 100,000–120,000 deaths alone yearly among 3–5 million cases and potentially 1.4 billion people living at risk in endemic countries.

While several pathways of disease transmission through contaminated drinking water are known, interventions at the source level and water treatment and storage systems at household level (HWTS) both provide immediate, temporary solutions to improve the quality of drinking water where piped systems are not available. The latter options are usually affordable and easy-to-use technologies that can be applied by individuals independent of the origin of the water [7]. To be effective, however, these solutions rely on their correct, consistent, and continued application [8]. Even slight declines

in compliance, for instance small amounts of untreated water consumed on a few days in the year, can cause up to 90% of the expected beneficial effects of water treatment to vanish [9]. It is therefore essential to couple the provision of technological solutions with behavior change campaigns [10–12].

Behavior change strategies attempt to address key drivers or motivators in local populations to foster the adoption and continued usage of targeted technologies and related behaviors. Behavior change strategies based on psychosocial surveys which are tailored to the local populations' mindsets have been shown to outperform standard approaches, which often only address risk awareness and a few other factors such as knowledge of disease prevention [13]. Several factors at the personal and social level—such as social norms, status, self-efficacy convictions, and the like—have been shown to be important predictors for the success of promotion campaigns targeting a range of health-relevant behaviors [14–17]. Successful promotion strategies have also been shown to surpass outside stakeholders' project goals and definitions of outputs by rather taking into account multiple perspectives, especially local populations' views, attitudes, motivators, and fears [18].

Health psychology theory can help to identify and assess key drivers for health behaviors across countries and cultures. One integrating framework is the Risks, Attitudes, Norms, Abilities, and Self-Regulation (RANAS) model, which has been designed specifically for deployment in developing countries [19]. It incorporates elements from a variety of established health behavior theories. By operationalizing and comparing several psychosocial factors between performers and non-performers, it can help to identify the relevant drivers of behavior in a given population sample.

While the initial uptake or adoption of a new or alternative behavioral option is one aspect, the other is its sustained usage or continuation over time. A behavior change process can therefore be divided into (a) initiation of new behaviors and (b) their continued usage over time, sustained by prevention from relapse, a process which can eventually lead to habit formation [20]. However, factors that lead to behavioral continuation are often not the same as for initial uptake. Further, such factors are less understood from a health psychology perspective [21] which could be a reason why many programs fail to sustain behavior change.

Compared to behavioral uptake, the subsequent process of behavioral continuation has clearly been under-studied to date but should be of particular interest from several perspectives. Intervention campaigns should not only target factors for initial uptake but also those which promise long-term behavior change so as to close the gap often reported in the literature between successful initial uptake and failure to improve behavioral maintenance [22]. A more accurate knowledge of factors important for the continuation of health relevant behaviors could enhance existing behavioral models and expand the scope of practical campaigns developed from them.

Further, many programs do not follow up after an initial behavioral promotion or measure only short-term goals. A better understanding of factors for behavioral continuation can help to define criteria for measuring success in the long term. From a public health perspective, it is of great interest that programs not only understand factors driving initial behavior change but also guarantee long-term continuation to efficiently concentrate funds on reaching sustainable project goals.

A previous study in Chad examined the psychosocial factors explaining behavioral uptake of drinking-water chlorination as a means to prevent cholera outbreaks. The most important factors for the promotion of drinking water chlorination were risk perceptions, social norms, and self-efficacy convictions, which differed significantly between survey participants who were performing water treatment and those who were not at the time of survey (details can be found in [23]).

In this study, we are interested in the process of behavioral continuation. We examine which behavioral factors play an important role in maintaining behavior by utilizing the baseline data from [23]. To observe what changes in psychosocial factors occurred over time in different user groups, a second survey was conducted in the same study sample. No further interventions had taken place in the meantime.

This study may help to foster an understanding of which individual-level factors explain the continuation of health behaviors such as drinking-water treatment. This may improve behavior change

programs by focusing campaigns on psychosocial factors relevant to behavioral continuation and by defining long-term goals for program evaluation.

The main objectives of this study is to examine psychosocial factors for drinking water treatment in a sample population over time. The objective is to identify psychological factors for behavioral continuation. We compared people who continued drinking water chlorination with people who stopped treating their drinking water to identify differences in the mindsets of the different groups. We show (a) which factors differ between the two groups initially; (b) which factors change over time; and (c) which factors develop differently for those people who continue water treatment compared to those who stop doing so. Therefore, we address the following research questions in our analysis:

(1) Which psychological factors show differences between those continuing and those stopping water treatment?
(2) Which psychological factors change over time when people continue or stop water treatment?
(3) Which psychological factors change differently over time between the two groups?

2. Materials and Methods

The field research was carried out in communities in the Lake Chad Basin, a region frequently hit by cholera epidemics where securing access to safe drinking water is one of the highest priorities [24]. A number of sites were chosen in both urban and rural settings in Chad, in a region near the frontier with Cameroon and bordered by a two-river system, the Chari and Logone. The urban sites were neighborhoods of N'Djamena, Chad's capital city with a population of about 3 million; rural sites were located along a 400 km strip north and south from there. Target communities were chosen based on recommendations by the Ministry of Health in Chad. In 2004, the national level of access to safe drinking water was 51%; however, large differences exist across the country [25]. According to 2015 figures, 72% of the urban population and 45% of the rural population had access to improved water—which is not necessarily safe [26].

Households in which a child under the age of five years was living at the time of the baseline survey were eligible to participate in the study. Young children usually carry the largest burden of diarrheal disease and so benefit most from improvements in water, sanitation, and hygiene [27,28]. Households were chosen based on a random route procedure [29]. The baseline survey will hereafter be referred to as "survey 1" Assisted face-to-face interviews were conducted with the primary caregiver in charge of childcare and household work, most of whom were female (95%). On average, participants were 31 years of age (standard deviation (*SD*) = 11.6) and 8.6 (*SD* = 5.3) persons shared one household.

Data on survey 1 was collected during two distinct periods due to rescheduling during the project. The first 600 households were interviewed in Chad in November and December 2013. Although it was originally planned to survey the same number of households on the Cameroon side of the river system, this plan had to be dropped due to security issues arising at the end of 2013. Instead, another 400 households were interviewed further south on the Chad side in the Mayo Kebbi Est district. In total, interviews with 1017 primary caregivers were conducted in survey 1. A structured questionnaire of one hour's duration was administered using electronic tablet devices. The local study team, comprising two field supervisors and ten interviewers, received seven days' training on the study rationale and on using the survey instruments, including a piloting phase in the field. Follow-up data were collected in an evaluation survey in October/November 2015 ("survey 2").

The original study sample size was reduced for this analysis, for several reasons. During the baseline study, only 304 (30.0%) of all interviewees stated that they used some kind of water treatment in their household. This group is the sample of interest for this study. Of these households, 213 (70.1%) could be interviewed during the second survey. Dropouts occurred for several reasons; 40 households had moved away (13.2%) and 23 study participants were travelling and thus not present during the days of the follow-up assessment (7.6%), five participants (1.6%) had deceased, one family was

mourning the death of a family member. Seven participants refused to be interviewed (2.3%) a second time and 15 (4.9%) households could no longer be identified.

Between the two surveys, an intervention campaign was planned and carried out by the Ministry of Health in collaboration with local health care facility staff to promote drinking water chlorination based on the World Health Organization's guideline for drinking-water quality [30]. However, that intervention only reached a minority of the sample under study here. Households that participated in the Ministry's promotion activity were excluded from the present analysis (N = 16). This leaves 197 households that are eligible for inclusion in this sample. Of these, 86 (43.7 %) reported that water treatment was still done in their households, while 111 (56.3 %) did not report any water treatment activity at the time of the second survey. The first group will hereafter be referred to as "continuers" of water treatment; the second group will be termed "stoppers". Drinking water chlorination was cross-validated via residual chlorine testing.

The survey covered general information on individual subjects' and households' demographics, assessed wealth, available water sources, knowledge of water treatment technologies, and self-reported water treatment behavior. It also contained questions about a number of psychosocial concepts that are used to measure behavioral factors concerning drinking water treatment. Key terms and questions were translated into local Arabic and other languages spoken in the region together with the team of interviewers to guarantee uniform understanding. Questions on psychological constructs were generally answered on a five-point rating scale with predefined responses from which the interviewee was asked to choose the most appropriate.

The psychological concepts included in the survey instruments are briefly described below. Definitions of factor blocks were taken from the framework guideline [31]. Individual questionnaire items were combined to form scales for each psychological construct. Table A1 in the Appendix A shows the factor blocks, factors, and exemplary items for each factor, the answer format, number of items, and scale reliability where items were combined. The scale range for all items was standardized to form a uniform range from 1 as minimum to 5 as maximum scale values; items with a reverse answer format were recoded to provide consistently structured scales.

The block of risk factors addresses a person's understanding and awareness of the health risk. This includes individuals' perceptions of their susceptibility to diarrheal disease and the estimation of the severity of its consequences to their own health and life. It also includes basic health knowledge about sources of disease and disease transmission, as well as what can be done to prevent disease.

Attitudinal factors represent a person's positive or negative stance towards a behavior. In the present study, taste perceptions of treated and untreated water were of interest. Further, potential or perceived costs and efforts compared to the benefits of treating drinking water were assessed.

Norms represent the perceived social pressure towards a behavior. Existing social norms are one of the strongest influences for health behaviors in people, as has been shown in a recent review [32]. The RANAS model therefore addresses three dimensions of normative factors. One is the perceived behavior of others, for instance, how many other people perform or do not perform a behavior. Another dimension is how far others approve or disapprove of a certain behavior and whether it is publicly encouraged, for example, by influential people. A third dimension is the strength of an individual's own obligation, what one thinks he or she should or should not do. In this study, two additional factors were added to the RANAS norm block. Social support describes how strongly an individual is supported in his or her attempt to perform a certain behavior. In this study, the questions concerned perceived social support, describing not necessarily the actual support the individual received in treating drinking water but how much he or she felt supported [33]. A second question concerned the frequency with which drinking water treatment is or was a topic of discussion among subjects. This is termed "social discourse".

Abilities represent a person's confidence in her or his ability to practice a behavior. Ability factors address the concept of self-efficacy, which is seen as one of the key determinants in all stages of behavior change [34]. The ability factor block includes a subject's knowledge of how to carry out—and

perceived confidence in carrying out—the steps necessary for a behavioral goal, to deal with difficulties that might arise or to recover from drawbacks or from having stopped to perform the behavior (action, maintenance, and recovery self-efficacy).

Self-regulation represents a person's attempts to plan and self-monitor a behavior and to manage conflicting goals and distracting cues. This includes making plans to facilitate the behavioral execution in the future and how to cope with arising difficulties. It also comprises self-monitoring activity; that is evaluating and correcting one's own progress towards a behavioral goal and to remind oneself of existing intentions. Commitment captures the concept of personal dedication towards a behavior, which can itself moderate behavior [35]. Habit further captures the extent to which a behavior is executed automatically, without having to consciously think about it. The higher the level of habituation to a certain behavior, the more likely it is to be executed in relevant situations due to the automatic activation of learned patterns [36]. Habit can be seen both as an outcome of previous behavioral factors and as a predictor of behavior [35].

Lastly, individuals' intention to treat water was captured as the level of their volitional strength [37]. Intention can be regarded as the outcome of certain of the previous constructs, but it can also act as an intermediate variable in explaining behavior.

Current self-reported water treatment behavior was measured by asking the question "Do you do anything to make the water [designated for drinking in the household] safe to drink?" Further, reasons for treating or not treating water were inquired using open-end questions.

General linear models (GLM) for repeated measures were calculated to examine (a) differences in means between groups of users; (b) differences in time between the surveys; and (c) differences in groups over time.

The first analysis compares the overall means of the two user groups over both surveys. Significant results for a given factor show a general difference between the two groups that exists disregarding the time factor. The second analysis compares the mean values between the two surveys disregarding group differences and thus only shows general increases or decreases over time. This represents the development of factors from baseline to follow-up assessment for both user groups taken together. The third analysis examines differences between the two groups and between the two surveys. It analyzes whether the means of the two groups develop differently over time and is represented by the interaction term between group and time. These three steps of analysis were run for each individual factor separately. The threshold for significance was corrected at alpha = 0.0025 for multiple comparison with 29 factors [38]. All calculations were run using the IBM Corp. (Armonk, NY, USA) SPSS Statistics software package.

The field study was approved by the Ethics Commission at the University of Zurich, Switzerland. In-country research authorization was obtained from the Ministry of Health in Chad. Local authorities were briefed and asked for permission at each step of the survey. Oral informed consent was obtained from participating subjects due to high illiteracy in the study area.

3. Results

Figure 1 depicts a graphical representation of the survey results for all psychological factors, showing the mean values for the answers of the two groups of continuers and stoppers at both surveys. The scale range is 1 to 5 and all factors have been standardized and recoded so that 1 always represents the scale minimum and 5 represents the maximum possible value. Low values stand for less favorable results concerning water treatment behavior. For example, a low personal risk perception for diarrheal disease, weak social norms, and high perceived costs of drinking water chlorination are all interpreted as reducing the probability of a person performing water treatment. Higher values are more favorable for the target behavior. High perceived benefits, low costs, high social norms, and strong intention or commitment to drinking water treatment are expected to correlate with a high probability of that person performing water treatment.

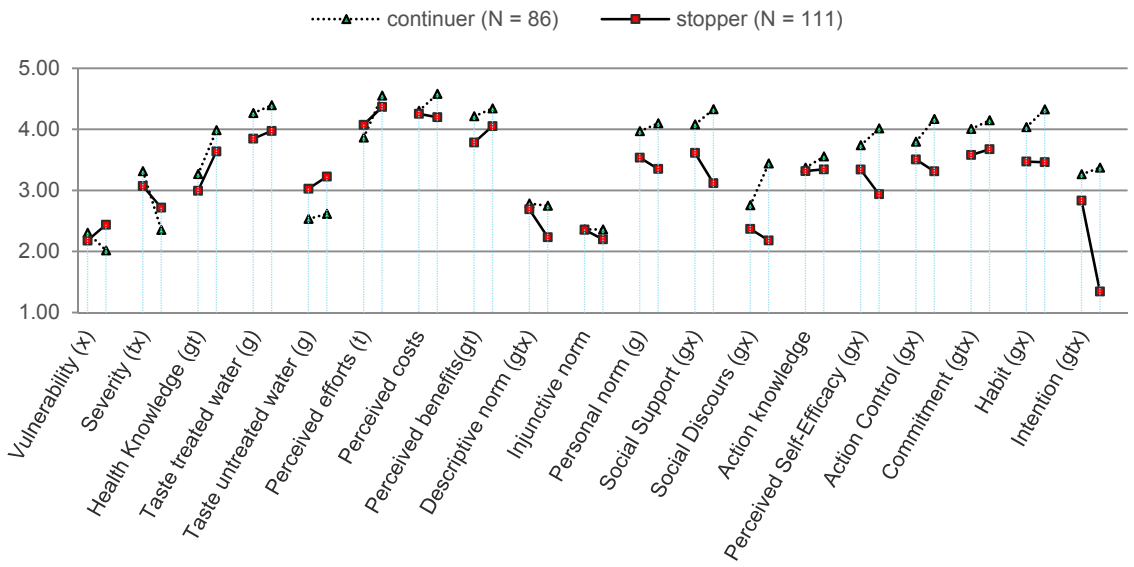

Figure 1. Graphical representation of results for all psychological factors divided by continuers (N = 86, triangles) and stoppers (N = 111, diamonds) of water treatment form survey 1 to survey 2. Note. (g) = significant group effect, (t) = significant time effect, (x) = significant interaction effect between group and time.

We first look at the results in three different ways. First, we compare the average mean values between the two groups of continuers and stoppers of water treatment globally over the two surveys. Secondly, we examine whether any changes occurred over time for a given factor, whether increasing or decreasing within the factor between the two surveys for both groups together. Thirdly, we look at the interaction between group mean values and time, which compares the development of a factor over time between the two groups. These three steps are done for each factor block separately. The third step is of particular relevance to our research questions.

The results from the general linear models for repeated measures indicate whether any of these comparisons are statistically significant. Table 1 provides the numerical values for the means in all factors for the two groups of continuers and stoppers at both surveys. It also gives the F values from the statistical analysis. The "group" value represents the magnitude of difference between groups, the "time" value represents overall change over time, and the "group × time" value stands for the interaction term between group and time point, which represents differences in progress between groups over time. If the group term is significant, there is an important difference in overall means between the groups of continuers and stoppers disregarding time. A significant time value means that the development over time of a factor is important, for instance, an important increase or decrease in the mean values occurs over time disregarding group differences. When the group × time interaction term is significant, the means for the two groups show a statistically significant difference in development over time; they progress differently.

3.1. Psychological Factors

No significant differences exist between the groups of continuers and stoppers of drinking water treatment regarding their estimation of the risk factors vulnerability for and severity of diarrheal diseases overall. However, there is a significant development over time in the severity factor – both groups estimate the consequences of diarrheal disease as less severe at survey 2 than at survey 1. This decrease is significantly stronger for continuers, who had higher scores at survey 1 than stoppers, but lower ones at survey 2, yielding a significant interaction effect. Health knowledge of diarrheal disease was already significantly higher for continuers at survey 1 and remained higher at survey 2, and there is a general increase in both groups.

Table 1. Results from GLM analysis. Means of continuers and stoppers of water treatment at survey 1, survey 2, and differences in means between surveys (1 → 2) for all psychological factors.

Factor/Survey	Continuer (N = 86)					Stopper (N = 111)					GLM: F-Value		
	Survey 1		Survey 2		1 → 2	Survey 1		Survey 2		1 → 2			
	Mean	*(SD)*	*Mean*	*(SD)*	*Mean*	*Mean*	*(SD)*	*Mean*	*(SD)*	*Mean*	*Group*	*Time*	*g x t*
Vulnerability	2.31	1.20	2.02	0.88	−0.29	2.18	1.04	2.44	1.14	0.26	1.712	0.026	6.42 *
Severity	3.31	1.26	2.35	1.37	−0.96	3.07	1.13	2.72	1.36	−0.36	0.211	30.182 *	6.282 *
Health knowledge	3.27	0.90	3.99	0.82	0.72	2.99	0.89	3.64	1.01	0.64	9.576 *	65.853 *	0.138
Taste treated water	4.27	0.76	4.40	0.72	0.13	3.85	0.93	3.97	0.95	0.13	20.748 *	2.441	0
Taste untreated water	2.53	1.42	2.62	1.16	0.08	3.03	1.29	3.23	1.13	0.20	17.358 *	1.328	0.232
Perceived efforts	3.87	1.18	4.55	0.77	0.69	4.07	1.15	4.36	0.86	0.29	0.004	22.486 *	3.799
Perceived costs	4.30	1.23	4.58	1.00	0.28	4.25	1.13	4.20	1.11	−0.06	3.343	0.997	2.523
Perceived benefits	4.21	0.75	4.34	0.69	0.13	3.78	0.90	4.05	0.77	0.27	16.968 *	7.35 *	0.898
Descriptive norm	2.79	1.03	2.75	0.94	-0.04	2.69	1.03	2.23	0.75	−0.46	9.538 *	7.363 *	5.324 *
Injunctive norm	2.36	1.32	2.36	1.27	0.00	2.36	1.33	2.20	1.17	−0.16	0.305	0.484	0.484
Personal norm	3.97	0.94	4.10	0.90	0.13	3.54	1.02	3.35	1.08	−0.18	30.165 *	0.091	2.76
Social support	4.08	1.09	4.33	1.00	0.25	3.61	1.28	3.12	1.54	−0.49	41.614 *	0.802	8.366 *
Social discourse	2.76	1.40	3.44	1.44	0.69	2.37	1.41	2.18	1.23	−0.19	33.634 *	3.373	10.461 *
Action knowledge	3.37	0.81	3.56	1.00	0.19	3.32	0.92	3.34	0.95	0.03	1.567	0.453	0.149
Perceived self-efficacy	3.74	0.81	4.01	0.72	0.28	3.34	0.88	2.94	1.13	−0.40	50.899 *	0.625	15.957*
Action control	3.80	0.91	4.17	0.97	0.37	3.51	0.96	*3.31*	*1.09*	*−0.19*	*18.038* *	*1.316*	*4.32**
Commitment	4.01	0.75	4.15	0.75	0.14	3.58	0.89	*3.67*	*0.75*	*0.09*	*18.923* *	*6.178* *	*0.965*
Habit	4.04	0.99	4.33	0.92	0.29	3.47	1.15	*3.46*	*1.06*	*−0.01*	*19.722* *	*1.226*	*0.098*
Intention	3.27	1.01	3.37	1.19	0.11	2.83	1.26	1.34	1.64	−1.49	80.738 *	29.256 *	38.837 *

GLM F-values, * statistically significant in bold at alpha = 0.0025, corrected for multiple testing according to Cohen [38]; N = 197, italics: reduced data due to missing self-regulation factors stoppers without intention at survey 2: N = 47.

When asked for rating the taste of treated and untreated water, a clear pattern emerges between the two groups. Continuers rate the taste of treated water better at both surveys, while stoppers liked the taste of untreated water better. No significant development occurred over time. The efforts perceived necessary to treat drinking water were rated equally by the two groups at both surveys. Additionally, this attitudinal factor developed over time for both groups, which means that there is no significant difference in progress over time. While no differences existed between groups or surveys for monetary cost estimates, there was a significant difference in the perceived benefits of water treatment between the two groups and between the surveys. Continuers rated the benefits higher at both surveys, and generally this attitude evolved positively over time for both groups.

Significant differences in the perception of social norms between groups exist in almost all factors in the norm block. Continuers of water treatment think that more people engage in this behavior than stoppers, they feel a higher personal obligation to do so compared to stoppers, support from the head of household for the responsible person is higher, and water treatment is more often a topic of discourse among those households where water treatment is continuously performed at both surveys. Additionally, the perception of the descriptive norm decreases significantly over time for both groups. However, this is mostly due to the significantly stronger decrease for stoppers, while the perception of others' behavior remains almost unchanged for continuers.

Further significant interactions between group and time were observed for social support and social discourse. While both of these factors increase for continuers, who perceive more support in carrying out water treatment and discuss it more often than before, they decrease for stoppers, which means that social support and discussing it diminishes within this group.

A similar pattern was observed when looking at the perceived self-efficacy to engage in water treatment. While continuers already felt more confident in their abilities to perform and continue to execute the steps necessary for water treatment even when experiencing difficulties or drawbacks at survey 1, this difference had significantly increased by survey 2. Continuers felt even more self-confident, while self-confidence weakened in stoppers.

Significant differences also exist for the block of self-regulation factors. Continuers stated that they put more effort into monitoring and controlling their behavior at both surveys. While they evolve positively, action control decreases significantly for stoppers over time. Commitment to water treatment shows slight positive progress over time for both groups; however, continuers score significantly higher at both the first and the second measurements. The two groups also differ significantly in the strength of self-reported habit for water treatment. While there is no significant development over time, continuers report a much stronger habit at both surveys.

The strength of intention to treat drinking water shows some of the greatest discrepancies between continuers and stoppers at all three steps of analysis. Continuers had stronger intentions at the first survey, and while there is significant progress over time overall, continuers develop positively towards an even stronger intention, while intention decreases dramatically for stoppers from survey 1 to survey 2.

3.2. Additonal Factors

The RANAS model takes into account a number of external (personal, social, and physical) factors that can influence behavior. The two behavioral groups were compared on a range of socio-economic factors to identify possible confounding explanatory variables. Household size and number of children were analyzed. While stoppers lived in slightly larger households and had more children below five years, these differences were not significant. Primary caregivers were compared in terms of age and their level of education and whether she was married. Household wealth was assessed computing an SES score taking into account whether the household owns a bed, table, radio, television, mobile phone, or a vehicle and whether the household is connected to electricity. Further, an overall hygiene was computed based on spot-checks done within the household. The burden of diarrheal disease was compared by rating the frequency of diarrheal incidence among the children below five. While

primary caregivers in households continuing water treatment had a slightly higher educational level, none of these factors yielded significant differences between continuers and stoppers. Distance and time to be travelled for a round trip to the primary source and back also did not differ significantly between groups. Details can be found in Table 2.

Table 2. Socio-demographic variables tested between behavioral groups.

Factor	Group	M	SD	F	*p*
Total number of household members	Continuer Stopper	9.27 9.32	5.764 6.145	0.003	0.959
Number of children below 5 years of age	Continuer Stopper	2.30 2.46	1.709 1.944	0.352	0.554
Number of children between 5 and 17 years of age	Continuer Stopper	3.27 3.23	2.584 2.750	0.009	0.925
Primary caregiver is married (percentage)	Continuer Stopper	0.87 0.90	0.336 0.300	0.402	0.527
Age of primary caregiver (in years)	Continuer Stopper	32.21 32.98	10.137 12.350	0.220	0.639
Level of education of primary caregiver *	Continuer Stopper	1.10 0.87	0.795 0.825	3.597	0.059
SES asset score *	Continuer Stopper	0.63 0.57	0.235 0.238	1.983	0.161
Overall hygiene score *	Continuer Stopper	0.53 0.47	0.159 0.159	1.689	0.200
Frequency of diarrheal disease among child under 5 *	Continuer Stopper	2.49 2.64	1.225 1.189	0.764	0.383
Distance to primary water source (in m)	Continuer Stopper	126.79 155.41	179.767 200.720	1.063	0.304
Total time for a round trip to primary water source (in min)	Continuer Stopper	14.05 11.90	13.364 10.110	1.610	0.206

Note. * The level of education was set to be "0" for "no school visited", "1" for "basic education" and "2" for"higher education". SES asset score is based on whether the household owned the following: bed, table, radio, TV, refrigerator, vehicle, cellphone, electricity; the overall hygiene score is based on a range of spot-check observations within the household (both range 0–1). Frequency of diarrheal disease among children below 5 years of age was rated between "never" – "several times a year/month/week" – "almost every day".

We investigated some other factors that possibly could distinguish continuers from stoppers. We looked at whether the study site or the setting between city and village had an influence on the proportion of people using water treatment. However, we could not find any important differences between these external factors and the two study groups. Detailed results displaying proportions of continuers and stoppers over these factors are displayed in Table 3.

We further inquired the primary sources households were using to get drinking water from and whether they had switched sources between the two surveys. A total of 24 continuers and 31 stoppers had switched to another primary source from survey 1 to survey 2. However, the number of relevant changes—i.e., switching from an unimproved to an improved source or vice versa was negligible. Of the continuers, seven households switched from an unimproved to an improved source and only one household from improved to unimproved. From the stopper households, four switched from an unimproved to an improved and five from an improved to an improved source. The large majority of households switching to a different source stayed within the classification of source they had been using before. Also, taste perceptions of treated and untreated water did not significantly differ between those households that had switched between sources in the meantime.

Table 3. Additional factors. Counts and proportions within group for continuers and stoppers.

Factor	Level		Survey 1		Survey 2	
			Continuer	**Stopper**	**Continuer**	**Stopper**
Setting	Rural	Count % within group	47 52.2%	63 51.6%		
	Urban	Count % within group	43 47.8%	59 48.4%		
Primary water source *	Surface water	Count % within group	1 1.2%	6 5.8%	0 0.0%	2 2.0%
	Street vendor	Count % within group	7 8.5%	2 1.9%	3 3.6%	5 5.1%
	Tap water	Count % within group	18 22.0%	33 31.7%	23 27.7%	29 29.3%
	Traditional (dug) shallow well	Count % within group	1 1.2%	1 1.0%	2 2.4%	0 0.0%
	Deep well pump	Count % within group	55 67.1%	62 59.6%	55 66.3%	63 63.6%
Change of water source	No	Count % within group			59 71.1%	73 70.2%
	Yes	Count % within group			24 28.9%	31 29.8%

* Not all households could be classified to a unique primary source.

3.3. Reasons for Water Treatment

When asked why or why not subjects were treating their drinking water, responses were given in an open question format and later classified into several categories.

Among all subjects at survey 1, reasons for water treatment mentioned were "to kill germs" (mentioned by 122 interviewees or 61.9%), "to avoid disease" (118; 59.9%), "to make water safe" (38; 19.8%), "stay healthy" (27; 13.7%), to "reduce the risk of diarrhea or cholera" (19; 9.6% or 16; 8.1%), and others (2; 1%). The same categories of reasons were mentioned in about the same proportions at survey 2 by those still continuing water treatment.

Stoppers at survey 2 mentioned several reasons for not treating drinking water anymore. Among those were "lack of material" (52; 46.8%), "lack of financial means" (40; 36%), others thought that "the water was already safe " (16; 14.4%), or simply thought of it as "not a habit" (7; 6.3%). Other reasons for not treating water were not knowing "how much chlorine to put in", the responsible person in the household was away travelling (both mentioned once).

3.4. Residual Chlorine Testing

In order to cross-validate self-reported water treatment, residual chlorine tests (WataBlue by Antenna Technologies Foundation, Geneva, Switzerland) were conducted on a sample basis when stored water was available at the household level. Out of 66 water samples tested, 36 (55%) were negative and 30 (45%) were positive.

However, there are several issues with the validation of drinking water chlorination. Some of the households that declared water treatment did not have stored water in the home at the moment of visit. Others explained they had not yet treated their water on that specific day or forgot to so. Some reported the likelihood of under-dosing of larger containers or the product had been finished in the last days and the head of household had not yet provided them with a new one. A number of households collecting water from a municipal tap declared they had expected the water to be treated on the level of the facility already which is why they did not add chlorine at the household level.

4. Discussion

In this study, we investigated the role of psychological factors in the continuation of drinking water treatment. To do this, we compared individual subjects in households where drinking water treatment was continued from one survey to a later one with similar individuals in households where treatment had stopped in the meantime. Based on a number of behavior factors from health psychology, we show how these two groups' mindsets differ from each other and evolve differently over time.

In doing so, we tried to identify factors which are relevant to the continuation of drinking water treatment. We looked at (a) which factors differed initially between the two groups; (b) which factors change over time between the two surveys; and (c) which ones evolve differently over time for the groups of continuers and stoppers.

Generally, it was observed that continuers of drinking water treatment display higher scores on the majority of psychological factors related to treatment behavior (except in the rating of taste of untreated water, which was higher for stoppers, as one might expect). This is true for results from the initial baseline survey at survey 1. In accordance with findings from similar studies and health psychology, this shows that important differences exist in the mindsets of people, and that these can be more or less predictive of how likely it is that they adopt such health-protective behaviors as handwashing, water treatment, and the use of adequate sanitation [39–46].

In addition to the initial differences, we find a number of these to be even more pronounced at the follow-up measure at survey 2, with some exceptions that shall be addressed later on, which means that there is a different evolution of factors over time between the two groups of subjects. This is especially the case for health knowledge, taste of treated water, perceived efforts related to water treatment, most of the normative factors such as descriptive and personal norms, social support, social discourse, action control from the self-regulation block, intention, commitment to water treatment, and related habits. Significant differences occur in the development of factors over time between the two groups. This was particularly the case for three of the normative factors, namely descriptive norm, social support, and social discourse. It was also so for perceived self-efficacy, intention for water treatment, and to some degree for action control. Generally, the pattern was that these factors evolved positively for continuers of water treatment, who displayed increased values at survey 2 compared to survey 1. This means that those subjects whose households continued to treat their drinking water from survey 1 to survey 2 developed a more positive mindset for drinking water treatment than their initial baseline values.

Continuers developed stronger social norms in favor of household water treatment. In particular, they had a stronger impression that more of their neighbors, close relatives, and friends engaged in water treatment, received more support from other household members, and talked about it more often than at survey 1. The same subjects also became more self-confident in their abilities to perform water treatment generally, uphold their behavior despite arising difficulties, and recover from drawbacks. This is in accordance with health psychology literature, where self-efficacy is said to be one of the most important drivers of behavior in all stages of behavioral execution [34,47]. In behavioral models that separate health behaviors into different stages (e.g., contemplation, intention building, behavioral execution, and maintenance of the behavior) having enough confidence has an important influence on whether or not the behavior is executed or upheld at every stage. Continuers also spent more energy monitoring their own actions, which is another important factor for behavioral maintenance found in the literature [21].

The intention to perform and to continue performing water treatment also intensified over time for continuers compared both to initial intentions and to those subjects who stopped doing so. This is in line with findings that the intention to engage in a certain behavior is already a proximate measure for the behavioral execution itself [37].

In contrast, stoppers can be characterized by a decrease in several factors. Subjects who stopped water treatment from survey 1 to survey 2 showed a decrease in all normative factors, which means they came to perceive the behavior as less common and desirable, felt less personally obliged, received

less support from their family members, and talked about the topic less often. Stoppers also became less confident in their abilities to always perform water treatment and spent less effort in monitoring their own actions; for instance, they reminded themselves about it less often. The strongest drop in all the factors analyzed was in their intention to perform water treatment, which corresponds closely with the change in behavior from treatment to no treatment.

A somewhat paradoxical finding is that of a reversed time trend for two risk factors, vulnerability and severity. In both, continuers of drinking water treatment scored lower on the scale than stoppers after starting from about the same baseline value. This is contrary to the general hypothesis that assumes continuers also develop higher values in these constructs, as we generally see higher values to be of positive predictive value for the target behavior. This means we would expect to find that sustainable users of water treatment have stronger fears of contracting diarrhea and its consequences, which would in turn foster their efforts to engage in protective actions.

However, it makes equal sense for subjects showing more protective behavior to feel less vulnerable to threats. This would mean a reversed causality from that described above. People who continue to treat their drinking water need fear diseases transmitted by their water less, and thus their perceived risk estimates are lower than those of people who do not protect themselves. When asked to rate the severity of consequences of diarrheal diseases, people might be responding to their actual experiences. Again, people engaging in protective behavior should be less susceptible to disease, experience fewer or milder cases, and subsequently rate the impacts on their lives as less severe. This finding is in line with the results of similar studies [48].

General increases over time were observed in some other factors, such as health knowledge, perceived efforts and benefits, and commitment, but without statistically significant differences in progress between continuers and stoppers. For these factors, it might be the case that there is a general, naturally occurring evolution, with people becoming more familiar with knowledge of disease and prevention. Perhaps other promotion activities took place in the same period as this study that we were not aware of. In addition, being subject to a survey and answering questions related to one's own health and health behaviors can also be seen as an intervention in itself and can lead to reconsideration of one's own standpoints and behaviors [49].

In summary, the psychological factors most important for the continuation of water treatment are perceived others' behavior, social support between family members, social discourse, positive self-efficacy convictions, and strong intentions in its favor. Additionally, monitoring one's own actions also seems to be an important factor for continued water treatment. These factors best discriminate between continuers and stoppers of drinking water treatment at the household level and should be considered when promoting sustainable behavior change towards drinking water treatment at the household level.

When comparing these results with the answers to the open question about reasons not to treat drinking water from the second survey, interestingly, the two most frequent ones mentioned by almost half of all stoppers were "lack of material" and "lack of financial means". We would expect this reasoning to be reflected in the results for psychological factors. Although the perceived costs for water treatment per se are reported to be very low to low by both groups with no significant differences between groups and over time, we can interpret both of these reasons to be reflected rather within the perceived self-efficacy. Chlorine products are widely available in the country and can even be found in small boutiques on the village level. This means that it is not necessarily actually difficult to get the material or pay for it, but it might rather be a problem of lacking confidence in being able to save and invest the money for it and remind oneself to go and purchase the product.

A number of additional factors external to the person questioned in the interview were examined regarding their possible influence to distinguish between the two user groups, but no important differences were found. On the other hand, the aim of this work is not to explain why some people stop while others continue treating their drinking water. The focus is rather on exploring differences in

the psychological mindsets between the two groups to generate ideas on how to support households in maintaining their current (positive) health behavior.

Based on these findings, we conclude that several psychosocial factors play a distinct role in the continuation of drinking water treatment. Factors that should be addressed with emphasis once people have adopted the desired behavior are the perception of social norms, especially the perception of others' behavior, social support and discourse regarding the topic of water treatment, strong intentions and beliefs in one's own capacity to perform treatment, and monitoring one's own actions.

For practitioners in the field, these findings can be of very useful in developing promotion activities that strengthen these factors and so foster sustainable behavior change. Highlighting existing social norms, especially the extent to which water treatment is perceived as common within a local community, could help motivate people to maintain drinking water treatment over time. Additionally, emphasizing mutual support mechanisms and encouraging public dialogue on the topic appear to be promising strategies. Providing how-to-do knowledge, facilitating resources, and demonstration or guided practice can help to strengthen peoples' beliefs in their own capacity. Additionally, prompting self-monitoring, for instance by providing memory aids and giving feedback on current performance, could help to prevent subjects from stopping and thus maintain the behavior.

When considering the stages of behavior change discussed in the literature, it might also be useful to assess what level of behavior different individuals are at and how firmly the target behavior is already established within a population. Factors might play roles of differing importance depending upon whether fewer or more people have already adopted a new behavior, and different behavior change techniques should be used for different user groups as identified here. The present findings can also help to define long-term goals for sustainability with which programs can be evaluated beyond simply measuring the adoption of behavior.

One major weakness of continuum models is that they do not discriminate between different stages of behavior and thus usually account better for variance in intention and less in actual behavior [34]. Based on the critique of this gap between behavioral intention and actual behavior, a number of factors have been identified that play a stronger role once intention is already built up and the question is whether a behavior is not only intended or tried but maintained over time. These factors can be mostly accounted for by the self-regulation block and are more distinctively covered in the Transtheoretical Model of Behavior Change, for example [50]. In this sense, one could expect to find larger differences in the psychological factors from the self-regulation block. Next to the important differences between continuers and stoppers of water treatment that are present in some of the norm factors, this actually seems to be the case with consistently strong effect for self-efficacy perceptions, action control, commitment, and habit.

To some extent, focusing too much on the factors for initial adoption might also actually decrease the motivation of already users and thus continuation of behaviors. As has been shown, initiation of behaviors is more often motivated by expectancies of benefits, while the motivation for continuation is measured regarding the actual satisfaction of reaching the expectations [21]. This highlights the importance of carving out what factors are distinctively important for behavioral continuation compared to initiation. Such findings might support the usage of stage models that differentiate between non-users, new adopters, and long-term users and to know what is necessary to support these different groups in their behavioral motivations respectively.

There are several limitations to this study that should be mentioned. Self-reported behavior is always subject to diverse mechanisms of bias [51–53]. These can happen involuntarily or unconsciously but may also be based on deliberate false information from the subject [54]. Involuntary biases are based on well-studied cognitive processes which are usually not accessible to the respondent, such as recall errors and other memory effects [55] and the reduction of cognitive dissonance [56], which can lead to a distortion of information. On the other hand, information is also often intentionally falsified for different purposes. This can be the case when people hope to benefit from giving specific answers, especially in a campaign program or other circumstances in which answers tailored to meet

expectations or appear socially desirable [57]. While other methods exist to measure behavior, these bear other disadvantages. For example, direct observations may be more valid, but these are usually much more expensive and time-consuming than self-report [58].

Residual chlorine was not tested systematically in all households during both surveys. Stored water in households declaring current water treatment were tested on a sample basis during survey 2. These results suggest that the actual rate of water treatment might be lower than what we found from the self-reported data. This is what can be expected when asking people about socially desired health behaviors [59] such as in the WASH sector [60]. However, to properly validate self-reported drinking water treatment, a more sophisticated approach would have been necessary. People do not necessarily treat their drinking water every day or at each time water is collected. Findings from qualitative answers also suggest that participants explained they had not yet treated on that day or that they had run out of product although they are currently treating their water on a more or less frequent basis. People integrate their behavior over time, that is they report what they have been doing in the recent past. This is something a one-point objective measure cannot display. Further work is necessary to study the effects of over-reporting in drinking water treatment and in finding means for validation that integrates data over time.

The problem of bias in self-reported data has been addressed in the design of this study. While we expect some of the mechanisms mentioned above to influence the data, these effects should be the same for all subjects under study here regardless of the behavioral group. By comparing different groups from the same sample, interviewing them with the same instruments, we expect the problem of bias to be equally distributed. Further, it has been shown that successful interventions in changing behavior can be designed on the basis of self-reported behavioral data [15–17,61,62]. It might not be relevant after all to measure exact behavior and to validate self-reports about it when we can still explain what factors differentiate between users and non-users of technologies or groups of high and low performers of relevant health behaviors.

Another difficulty exists in measuring self-regulation factors in people currently not engaged in the behavior under study. More specifically, stoppers who stated no intention to treat their drinking water at survey 2 could not answer most of the factors from this last block. It seems infeasible for them to give information on the effort they currently put into monitoring a behavior they do not show, remembering to carry it out, or planning what to do in the case of relapses. The same is true for the strength of commitment or questions about current habits, which were repeatedly not understood or simply not answered at all by stoppers without intention at survey 2. However, while no information exists for self-regulation factors in these subjects, the related questions could still be answered in a hypothetical way by stoppers who at least reported some intention to treat water. The study size is therefore reduced for the self-regulation block, and corresponding results should be interpreted with caution. Even though one could assume that these factors would be rather low for the stoppers at survey 2, we did not try to estimate or impute values for this group. However, we can infer the effects of these factors to be underestimated, since the subjects with the potentially lowest values are no longer represented in the results. The problem of measuring self-regulation in subjects not engaged in a behavior should be given more attention in future research these factors are of particular interest for the continuation of health behaviors [21].

Ideally, the level of behavioral execution together with psycho-social factors would be measured repeatedly over a period in a multi-survey study. This would allow a much more detailed investigation of the mechanism underlying behavioral continuation, especially the change between the stages of behavior change from adoption to continuation to habit formation proposed in the literature [63]. The present study only offers two surveys with a period of almost two years between them, possibly subject to a range of personal or general extraneous influences. It therefore only serves as an approximate examination of some mechanisms for behavioral continuation. For future research, we thus propose to follow a possibly smaller sample size over time in a more tight-knit survey study

to understand better how long subjects have been treating their drinking water, exactly when and for what reasons they stop or why they would possibly also restart doing so.

Further, a substantial proportion of households could not be interviewed during the second survey. In most cases, these households were no longer living within the often highly fluctuated neighborhoods or had been on duty travel at the time of the second visit and we assume attrition to have happened on a random basis. Only a small minority (<3%) refused to participate in the second survey.

5. Conclusions

The mindsets of groups of people who continued or stopped treating drinking water in their households have been compared regarding their mindsets concerning this behavior. Individual psychosocial factors involving social norms, perceived self-efficacy for continuation, action control mechanisms, and intention to maintain the behavior have been identified as important factors distinguishing individuals in households where drinking water treatment is continued from those where this had stopped. Focusing on these factors might improve promotion strategies and the definition of evaluation criteria and thus enhance programs targeting sustainable behavior change. However, a more detailed approach is suggested to the study of underlying psychosocial factors for behavioral continuation and possibly the use of stage models.

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Appendix A

Table A1. Example items from the original questionnaire.

Factor Block	Factor	Example Item from Original Questionnaire	Answer Format	N Items	Reliability
Risk	Vulnerability	Generally, how high do you feel is the risk that you get diarrhea?	very low–very high	5	0.925
	Severity	How severe do you rate the impact on the health of your child below 5 years when it has diarrhea?	not at all severe–very severe	2	0.894
	Health knowledge	Can you name the major causes for getting diarrhea?	open questions; rating	11	sum score
Attitudes	Feelings	How much do you like or dislike the taste of treated drinking water?	very much dislike it–very much like it	1	—
		How much do you like or dislike the taste of untreated drinking water?	very much dislike it–very much like it	1	—
	Beliefs about costs and benefits	How time-consuming is it for you to treat your drinking water?	not at all time-consuming–very time consuming	2	0.512
		How expensive is it for you to treat your drinking water?	very expensive–not at all expensive	1	—
		How certain are you that treating your drinking water can prevent you and your family from getting diarrhea?	not at all certain–very certain	5	0.824
Norms	Others' behavior	How many of your greater family and friends treat their drinking water?	(almost) nobody–(almost) everybody	2	0.779
	Others' (dis)approval	People who are important in the community (e.g., Imam, Chief of village, etc.) how much do they promote that you should treat your drinking water?	not at all–very much	1	—
	Personal importance	Do you feel a personal obligation to treat your drinking water?	not at all–very much	2	0.432
	Social support	How strong does the head of your household support your family in treating your drinking water?	not at all–very much	1	—
	Social discourse	How often do you talk about water treatment with other people?	never–(almost) every day	1	—

Table A1. *Cont.*

Factor Block	Factor	Example Item from Original Questionnaire	Answer Format	N Items	Reliability
Ability	How-to-do knowledge	After chlorination, you have to wait at least 30 min until the water is safe to drink.	closed questions; yes/no	8	sum score
	Confidence in performance and continuation and recovering	How certain are you that you will always be able to treat your drinking water before drinking?	not at all certain–very certain	5	0.846
		How confident are you that you will be able to treat your drinking water even if you do not feel like doing so in the moment?	not at all confident–very confident		
		How confident are you that you will be able to continue to treat your drinking water even when you have forgotten to do this for a while?	not at all confident–very confident		
Self-Regulation	Action planning	Do you have any plans how to make sure that you can always treat your drinking water?	open questions; rating	1	—
	Action control	How strongly did you try to remember treating your drinking water at all times during the last week?	not at all–very strongly	3	0.791
	Barrier planning	Do you have a specific plan how to deal with difficulties?	open questions; rating	1	—
	Commitment	How much do you feel committed to treating your drinking water?	not at all–very much committed	3	0.532
	Habit	How much do you treat your drinking water rather automatically without having to think about it a lot?	not at all–very automatically	3	0.887
	Intention	How strongly do you intend to always treat your drinking water?	no intention–very strong intention	1	—
	Behavior		yes/no	1	—

Note. Example items for each individual factor from the original questionnaire sorted by factor blocks. Answer format, number of items per factor and scale reliability (alpha) are given where individual factors have been combined. Answer formats are usually represented on a five-point scale, the endpoints of which are given in the table, except for open/closed questions which were rated afterwards. All factors scale ranges were standardized and recoded where necessary to fit on a scale from 1 to 5.

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