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The role of commitment strength in enhancing safe water consumption: Mediation analysis of a cluster-randomized trial

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Objectives. The objectives of this study were to investigate the importance of commitment strength in the theory of planned behaviour (TPB) and to test whether behaviour change techniques (BCTs) aimed at increasing commitment strength indeed promote switching to arsenic-safe wells by changing commitment strength.

Design. A cluster-randomized controlled trial with four arms was conducted to compare an information-only intervention to information plus one, two, or three commitment-enhancing BCTs.

Methods. Randomly selected households (N = 340) of Monoharganj, Bangladesh, in seven geographically separate areas, whose members were drinking arsenic-contaminated water at baseline and had access to arsenic-safe wells, participated in this trial. The areas were randomly allocated to the four intervention arms. Water consumption behaviour, variables of the TPB, commitment strength, and socio-demographic characteristics were assessed at baseline and at 3-month follow-up by structured face-to-face interviews. Mediation analysis was used to investigate the mechanisms of behaviour change.

Results. Changes in commitment strength significantly increased the explanatory power of the TPB to predict well-switching. Commitment-enhancing BCTs – public self-commitment, implementation intentions, and reminders – increased the behaviour change effects of information by up to 50%. Mediation analyses confirmed that the BCTs indeed increased well-switching by increasing commitment strength. Unexpectedly, however, mediation via changes in behavioural intentions was the strongest mechanism of the intervention effects.

Conclusions. Commitment is an important construct to consider in water- and health-related behaviour change and may be for other health behaviours as well. BCTs that alter behavioural intentions and commitment strength proved highly effective at enhancing the behaviour change effects of information alone.

Statement of contribution

What is already known on this subject? Millions of people drink contaminated water even if they have access to safe water alternatives and despite increased awareness of the consequences to health. The theory of planned behaviour (TPB) and commitment strength are predictive of safe water

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consumption. The potentially commitment-enhancing behaviour change techniques (BCTs) – reminders, implementation intentions, and public self-commitment – can promote health behaviours, including safe water consumption.

What does this study add?

- Changes in commitment strength significantly added to the prediction of switching to arsenic-safe wells by the TPB.
- Information-plus-BCTs aimed at increasing commitment strength led to >50% more well-switching than information alone.
- Behaviour change effects of the BCTs were mediated by changes in commitment strength and behavioural intentions.

Nearly 800 million people lack access to safe drinking water (United Nations Children's Fund & World Health Organization [WHO], 2012). Unsafe drinking water (jointly with a lack of sanitation and hygiene) accounted for 3.8% of the deaths in low- and middle-income countries in 2004 (WHO, 2009). Besides the provision of affordable, improved water sources, behaviour change is vital to ensure safe water consumption and to mitigate waterborne diseases. While early research in this domain was largely qualitative and without theoretical basis (e.g., Hoque *et al.*, 2004; Opar *et al.*, 2007), theory-based psychological research has advanced. Factors from the protection motivation theory (Mosler, Blöchliger, & Inauen, 2010; Rogers, 1975), the transtheoretical model (Kraemer & Mosler, 2011; Prochaska & DiClemente, 1983), and the theory of planned behaviour (TPB; Altherr, Mosler, Tobias, & Butera, 2008; Fishbein & Ajzen, 2010; Kraemer & Mosler, 2012) have successfully predicted safe water consumption. From such models, theory-based behaviour change techniques (BCTs) can be derived to enhance safe water consumption. These are likely to render greater behaviour change, than interventions built on the common belief that people do not carry out health-protective actions due to a lack of knowledge (cf. Michie & Prestwich, 2010). Besides testing the efficacy of such interventions, it is equally important to investigate their underlying mechanisms (Michie & Abraham, 2004). This can enable the refinement of behaviour change interventions and the drawing of inferences about behaviour change theory (Michie & Prestwich, 2010).

Predicting behaviour change: Motivation and commitment

When initiating a new behaviour, such as switching to an alternative water option, motivational factors can be important. A well-evidenced and convincingly parsimonious theory with regard to motivation is the TPB (Fishbein & Ajzen, 2010). The theory postulates that beliefs about the consequences of a behaviour (i.e., attitude), which behaviours are approved by others (i.e., subjective social norm), and the control one has over performing a behaviour (i.e., perceived behavioural control [PBC]) form behavioural intentions, which, in turn, jointly with PBC, predict behaviour. However, for planning theory-based behaviour change, these constructs are quite broad. A fruitful approach for deriving theory-based BCTs is to further specify the factors of the TPB in order to identify modifiable behavioural determinants. Instead of subjective norms, it has been shown useful to differentiate between injunctive and descriptive norms (Ajzen & Fishbein, 2005; Stok, de Ridder, de Vet, & de Wit, 2013). The former describes what a person thinks should or should not be done, and the latter represents people's perceptions of which behaviours

are typically performed. Furthermore, the differentiation of affective attitude (emotional beliefs, e.g., finding behaviour pleasant or unpleasant) and instrumental attitude (cost–benefit beliefs) has been deemed useful (Ajzen & Fishbein, 2005). Besides motivational factors, an abundance of research has shown the often superior importance of post-intentional factors for behaviour change (Schwarzer, 2008). One powerful but neglected post-intentional concept is commitment strength, which was introduced by Gollwitzer (1999).

According to Gollwitzer (1999), commitment strength reflects the actual strength of the decision to display a behaviour, which is induced by implementation intentions, that is, simple plans about when, where, and how to exhibit the behaviour. Tobias (2009) generalized this concept to cases where there are no implementation intentions; he proposes commitment to be a tension state experienced by a person to perform a behaviour, which affects behavioural performance in addition to behavioural intentions. For committed persons, performing the behaviour thus becomes an urge or need (in contrast to the cognitive intention), and the person feels satisfaction when performing the behaviour and is annoyed when failing to do so. Commitment strength is produced by the decision to perform a specific behaviour, which can be induced directly by interventions such as implementation intentions or by strong behavioural intentions (see Figure 1).

Empirical studies have demonstrated that commitment strength is an important predictor of the adoption and maintenance of safe water consumption (Huber & Mosler, 2012; Kraemer & Mosler, 2012; Tamas & Mosler, 2011; Tobias & Berg, 2011), and it may be important for other health behaviours as well. As one of the two most proximal predictors

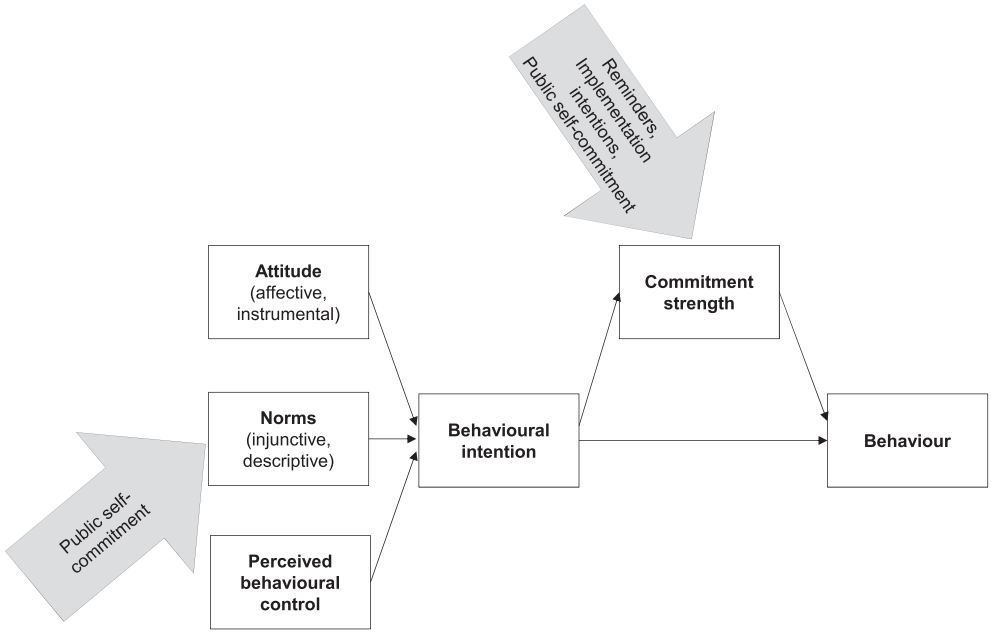

Figure 1. The theory of planned behaviour (TPB; Ajzen & Fishbein, 2005) extended by commitment strength. The grey arrows represent behaviour change techniques (BCTs) that are hypothesized to enhance commitment strength and norms, respectively.

of the described theoretical framework, commitment strength is very promising to target. Therefore, this study derives interventions to increase commitment strength. If these interventions indeed exert their behaviour change effects by changing commitment strength, this will further indicate the construct's importance in the behaviour change process. In any case, more information about the mechanisms of the behaviour change interventions studied here will emerge.

BCTs to increase commitment

There are several commitment-based BCTs (see, e.g., Mosler, 2012), and the results of a recent meta-analysis suggest their efficacy to change behaviour (Lokhorst, Werner, Staats, van Dijk, & Gale, 2013). The present study will focus on three of these BCTs – reminders, implementation intentions, and public self-commitment – that shall be discussed in the following.

Although commitment strength has rarely been integrated into behaviour change theory as a construct, self-commitment interventions have been applied widely in health psychology (also referred to as behavioural contracts; Abraham, 2012) and in environmental psychology (see Dwyer, Leeming, Cobern, Porter, & Jackson, 1993). 'A [self-] commitment is an oral or written pledge or promise to change behaviour (e.g., to conserve energy)' (Abrahamse, Steg, Vlek, & Rothengatter, 2005, p. 275). Self-commitment can be private or public. It is private if the promise to execute behaviour is given privately by the individual and public if self-commitment includes the announcement of the pledge to the community (Mosler & Tobias, 2007). Public self-commitment is likely to increase the effects of private self-commitment, because they have been shown to increase injunctive norms (Kraemer & Mosler, 2012). As the signs of public self-commitment make private behaviours visible to others, they may also increase descriptive norms.

Similar to private self-commitment are implementation intentions (Gollwitzer, 1999). They have been proved to be highly effective in modifying a series of health behaviours, such as reducing excessive alcohol consumption (Hagger, Lonsdale, & Chatzisarantis, 2012). Regarding their mode of operation, it has been shown that implementation intentions do not increase deliberation (Webb & Sheeran, 2008). Instead, they take effect by forming a link between the prospective situation and the behaviour, thereby increasing the accessibility of the situation and the association between the situation and the target behaviour (Webb & Sheeran, 2008).

With regard to water consumption, reminders have been found to increase commitment to disinfect drinking water (Kraemer & Mosler, 2012). The evidence on the efficacy of reminders to change behaviour, however, has been mixed. Differences have been attributed to the characteristics of the reminders and the amount of preparative activities for installing them (Guynn, McDaniel, & Einstein, 1998). Guynn *et al.* (1998) concluded that if a reminder is set up in an effective form, there is not much difference between implementation intentions and reminders. Tobias (2009) argued, however, that even optimally dispensed reminders may have varying effects due to differences in commitment strength; in other words, for more strongly committed persons, reminders should have stronger effects.

The present study

Arsenic-safe drinking water constitutes the water consumption behaviour in this study. Naturally occurring arsenic in ground water poses a great health threat, with

approximately 100 million people at risk of drinking water exceeding the WHO guideline of 1 μg of arsenic per litre (Amini *et al.*, 2008). Chronic arsenic intake can lead to arsenicosis, comprising skin diseases, cancer, cardiovascular diseases, and impaired neurodevelopment in children (Wasserman *et al.*, 2004). In Bangladesh, the most arsenic-affected country in the world, the agencies involved in mitigation have installed safe water options for affected communities and households, including deep tube wells that provide safe water by tapping deeper, arsenic-safe aquifers. Although accompanying awareness campaigns have had some behaviour change effects, there is scope for improvement (Johnston & Sarker, 2007). Therefore, augmenting commonly applied informational interventions with BCTs derived from the above-described theoretical framework should increase the behaviour change effects. Comparing an information-only intervention with information plus one, two, or three commitment-enhancing BCTs would further allow the investigation of the importance of commitment in the behaviour change process (cf. Williams, 2010); changes in commitment strength should mediate the increased behaviour change effects of information plus BCTs that target commitment strength as compared to information alone.

In summary, this study has two aims. First, the suitability of factors from the TPB, supplemented with commitment strength to predict behaviour change for arsenic-safe water, will be tested. It is hypothesized that positive changes in the TPB variables can predict switching to arsenic-safe wells (H1a). Furthermore, it is assumed that increased commitment strength will significantly contribute to predicting switching to arsenic-safe wells (H1b).

The second and major aim of the study is to investigate the efficacy and the mode of operation of BCTs that target commitment strength to increase arsenic-safe water consumption. To investigate this, the three BCTs – public self-commitment, implementation intentions, and reminders – were combined with information and compared with an information-only intervention in a cluster-randomized trial. Regarding behavioural effects, it is hypothesized that the information-plus-BCTs interventions more effectively promote switching to arsenic-safe wells than the information-only comparison intervention (H2). Regarding the mechanisms of the interventions, it is hypothesized that the information-plus-BCTs interventions, compared with the information-only intervention, will promote well-switching by changing commitment strength towards arsenic-safe water collection (H3a). In addition, it is assumed that public self-commitment affects social norms. Therefore, it is hypothesized that injunctive norms (H3b) and descriptive norms (H3c) will positively mediate the behaviour change effects of an information-plus-BCTs intervention that includes public self-commitment.

Methods

A cluster-randomized controlled trial with four parallel arms was conducted from December 2010 to April 2011 in Monoharganj, a subdistrict of Comilla, Bangladesh. With each arm, more theory-based BCTs were added, to increase commitment-enhancing effects and, thus, to achieve maximal behaviour change. To maintain a low-cost intervention, the simplest theory-based BCT was added to the information-only intervention: Reminders. In the second arm, implementation intentions were added to the reminders, and finally, public self-commitment, the most laborious and costly of the three BCTs, was added to all other BCTs. Four clusters of 2–4 villages each were randomly assigned to the information-only comparison condition (subsequently referred to as inf)

or to one of the three intervention-plus-BCTs conditions: (1) reminders and information (rem + inf); (2) implementation intentions, reminders, and information (imp + rem + inf); and (3) public self-commitment, implementation intentions, reminders, and information (pub + imp + rem + inf).

Clusters and participants

As the broader study area, three unions of Monoharganj were randomly selected: Hasnabad, Jhalam Uttar, and Maisatua. Of the 57 villages in these unions, 38 were excluded due to the ongoing behaviour change activities of the researchers' non-government partner organization, Village Education Resource Center (VERC). Of the 19 assessed villages, four more were excluded due to non-functional deep tube wells (see Figure 2). The 15 remaining villages were grouped into seven geographically separate clusters that were randomly assigned (random number generation) by the first author to the information-only comparison or one of the three information-plus-BCTs conditions.

The criteria for study participation of the households were (1) drinking water from an arsenic-contaminated tube well at baseline and (2) having access to an arsenic-safe deep tube well. The first criterion was assessed by self-report, and the second criterion was fulfilled by the selection of villages where at least one functional arsenic-safe deep tube well was available.

Sample size estimations with GPOWER (Erdfelder, Faul, & Buchner, 1996) yielded a total sample size of 280 households to detect a medium effect at the type I error probability of .05 and a power of 0.95 for the four intervention arms. Allowing an attrition rate of 20%, the persons responsible for drinking water collection (usually a woman) of 340 randomly selected households were interviewed at baseline. Of these, 90 did not receive the allocated interventions, and 24 were not available for follow-up (see Figure 2). Thus, in total, 226 households were assessed both at baseline and at follow-up, had received the allocated interventions, and were subsequently analysed. As expected, the vast majority of the respondents were female (223, 98.7%). Their average age was 35.8 years (SD = 12.0). About two-thirds of the respondents were literate (155, 68.6%) and had received an average of 5.4 years of formal education (SD = 3.8). The median monthly household income was 8,000 Bangladeshi Taka (approximately 96 USD).

Measures

A structured questionnaire was developed, pre-tested, and refined in a large pilot survey in Bangladesh for use in this study. The questionnaire items concerned water consumption, the TPB constructs, commitment strength, and socio-demographic characteristics. All psychological constructs were the averages of several items derived from the literature (for details, see Mosler, 2012) and adapted to the water consumption context. The response options were Likert scales (5-point for unipolar items and 9-point for bipolar items). To ensure the participants' comprehension of the questions, a hierarchical procedure was applied: The participants were first asked to choose one of three answer categories (e.g., rather like, rather dislike, rather neutral) and then were offered more detailed response options in the category they had chosen (e.g., dislike very much, dislike, rather dislike). Example questions for each construct and internal consistencies (baseline/follow-up) are presented as follows.

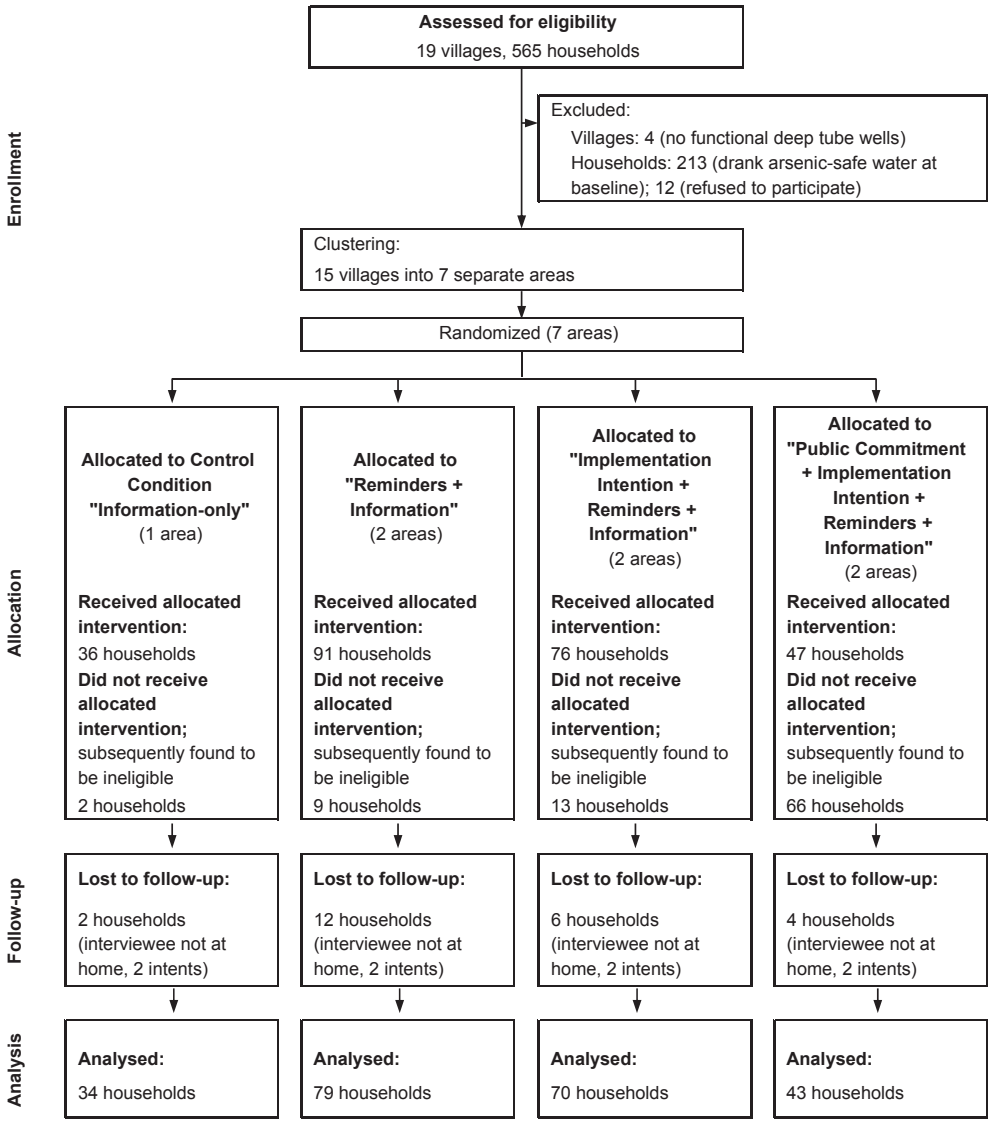

Figure 2. Participant flow through the cluster-randomized trial.

Water consumption

The participants were asked how many vessels of water from which sources and in total they collected for drinking on a typical day during the week preceding the survey. As all respondents had collected either all water from safe sources or all water from contaminated sources during that week, the final outcome was use (=1) or non-use (=0) of arsenic-safe water for drinking.

Affective attitude

This construct was measured with six items. The participants were asked, for example, whether they liked collecting water from the safe well, whether they felt ashamed to

collect water from there, or whether they liked the taste of the water (−1 = *dislike very much* to 1 = *like very much*; Cronbach's α [baseline/follow-up] = .83/.77).

Instrumental attitude

The perceived expenditures of time and effort were measured with two items. For example, 'Do you think that collecting water from the mitigation option is time-consuming?' (0 = *not at all time-consuming* to 1 = *very time-consuming*; Cronbach's α [baseline/follow-up] = .89/.99). The scale was inverted, so low values reflect low attitudes (i.e., high effort/time) and high values reflect favourable attitudes (i.e., low effort/time).

Injunctive norm

This was assessed with three items. The participants were asked, for example, 'Overall, how much would people who are important to you approve or disapprove that (or if) you collect water from the arsenic-safe water option?' (−1 = *they [would] disapprove very much* to 1 = *they [would] approve very much*; Cronbach's α [baseline/follow-up] = .90/.91).

Descriptive norm

Two items measured this, by asking the participants to state the number of people outside their families/of their village who collect water from the safe water option (0 = *almost nobody* to 1 = *almost everybody*; Cronbach's α [baseline/follow-up] = .80/.61).

Perceived behavioural control

This was assessed with three items. The participants were asked, for example, 'How difficult or easy it is to find time to collect water from the arsenic-safe well?' (−1 = *very difficult* to 1 = *very easy*; Cronbach's α [baseline/follow-up] = .90/.90).

Commitment strength

Three items assessed this. The participants were asked 'How important it was for them to collect water from the safe option, how committed they felt to collect water from the safe well, and how annoyed they felt if they forgot to collect water from there?' (0 = *not at all* to 1 = *very important/committed/annoyed*; Cronbach's α [baseline/follow-up] = .75/.87).

Behavioural intention

This was assessed with two items. Participants rated how strongly they intended to *always* collect water from the safe option and how strongly they intended to collect *all* their drinking water from it (0 = *not at all* to 1 = *very strongly*; Cronbach's α [baseline/follow-up] = .98/.99).

Changes in psychological constructs and well-switching

To operationalize change, the baseline values were subtracted from the follow-up values for each individual and psychological construct. Note that change scores only inform about the extent and the direction of change, not about a construct's absolute value.

Well-switching is reflected by the use of an arsenic-safe well at follow-up, because all respondents were non-users of arsenic-safe wells at baseline (0 = *non-user*, i.e., no change, 1 = *user*, i.e., changed behaviour).

Procedures

This study was conducted in strict compliance with the ethical principles of the American Psychological Association (APA), the Declaration of Helsinki, and in line with the ethics assessment procedures of the University of Zurich, Switzerland. The baseline and follow-up surveys were conducted in December 2010 and April 2011, respectively. Interventions were delivered 1 month before the follow-up, in March 2011.

Data collection

Ten professional Bangladeshi interviewers were extensively trained in a 5-day workshop to conduct structured face-to-face interviews of approximately 1 hr in duration. The training ensured that each interviewer attained the same easily understandable vocabulary tailored to the rural participants. A quality control team assisted the interviewers and certified the completeness of the filled-in questionnaires.

At baseline, households were randomly selected by the random route method (Hoffmeyer-Zlotnik, 2003). The interviewers first asked to speak to the person responsible for drinking water collection in the household. Then they assessed whether the household met the inclusion criteria. If yes, fully informed consent was obtained prior to conducting the interview. At follow-up, special care was taken to conduct the interview with the same household member who had been interviewed at baseline. If this person was not available, the household was revisited once.

Interventions

All interventions were delivered by health promoters recommended and supervised by the local non-government organization, VERC. The five female promoters (18–25 years of age) lived in the vicinity of the study areas and were trained by the first author and a local collaborator regarding arsenic, arsenicosis, and arsenic-safe water options, and on how to provide the interventions correctly. At each visit, the promoters first obtained fully informed consent and then conducted the intervention session, which lasted from 20 to 60 min, depending on the intervention condition (each BCT required approximately 20 min). The participants in the public self-commitment condition were also invited to join the commitment session held in their village 1 week after the promoters' visit. A supervisor from VERC assisted the promoters throughout and ensured the quality of the intervention delivery by means of random checks on health promoters and by revising documentation of intervention delivery (i.e., attendance sheets, copies of implementation intention forms, remaining reminders). Pre-testing ensured that illiterate participants would also understand all the materials. The BCTs are described as follows (intervention manuals are available at http://www.eawag.ch/forschung/ess/schwerpunkte/ehpsy/Beh_Change_Guideline_2012.pdf).

Information on arsenic, arsenicosis, and arsenic-safe drinking water options. Using a booklet with pictograms and photographs, the promoters informed the participants

about arsenic in shallow tube well water and its adverse health effects, which they described. Then the promoters explained where arsenic-safe water was located in the participants' communities (deep tube wells) and in general (all major arsenic-safe water sources in Bangladesh).

Reminders. A set of two reminders – a poster and a tag – was developed. The poster was designed to remind the participants just before their drinking water supply was finished to collect their water from the safe option. It depicted an almost empty *kalosh* (local vessel for water collection, pl. *kolshi*) and a woman going to collect water from a green-marked (arsenic-safe) tube well instead of a red-marked (arsenic-contaminated) one, which was crossed out. The tag was developed to remind the participants not to collect drinking water from the red-marked tube well. It contained pictograms showing the purposes for which the water should not be used: Drinking directly, boiling and then drinking, or cooking. Furthermore, the tag displayed the purposes for which the water could be used: Bathing or washing dishes. The promoters first explained the contents of the poster and then installed it where the participants kept their kolshi. Next, the promoters explained the contents of the tag and installed it at the arsenic-contaminated tube wells that the participants reported using.

Implementation intentions. As Bangladesh's rural residents are not used to living by the clock, pictograms were used that displayed typical tasks during the day for the 'when' part of the plans (e.g., sunrise, breakfast, bathing, etc.). First, the promoters asked the participants how many times a day they would have to collect water at the arsenic-safe deep tube well and then they asked the participants to specify a situation before or after which it would suit them best to collect water (e.g., before preparing lunch). Next, the participants named a specific deep tube well from where they committed to collect their drinking water. Subsequently, they specified how many kolshi they would collect each time they went and for which purpose (drinking, cooking, or both). Finally, the participants were asked to repeat the plan out loud after the promoter, to sign the implementation intention form by thumbprint and to keep it somewhere safe.

Public self-commitment. These were part-informational and part-commitment sessions. First, using posters, a team of two promoters and the supervisor again explained the same information about arsenic, arsenicosis, and arsenic-safe drinking water to the participants. Then they asked the participants to commit to drinking only arsenic-safe water from now on. The participants who committed were asked to read their implementation intentions to the group. At the end of the 2-hr session, tea and biscuits were offered to the participants.

Data analysis

All calculations were computed using IBM SPSS 20.0 (IBM Corp.). Hierarchical logistic regressions were performed to address whether changes in the TPB factors were predictive of behaviour change and whether changes in commitment strength would increase the explanatory power of the TPB. Multi-collinearity was acceptable (all variance inflation factors < 2).

Mediation analysis was used to determine the changes in which psychological factors mediated the behaviour change effects of the interventions. Procedures

proposed by Preacher and Hayes (2008) were followed using the SPSS macro 'PROCESS' (Hayes, 2012). For each intervention-plus-BCTs group, in comparison with the information-only group, simple mediation models were estimated. Thereafter, multiple mediation models were calculated to determine the relative importance of the significant mediators. Ninety percentage confidence intervals were computed by bootstrapping (5,000 resamples) to test for positive indirect effects of the interventions on behaviour change.

Results

Descriptive statistics and preliminary analyses

Table 1 displays the descriptive statistics for water consumption and all psychological variables for all intervention groups over time. The intercorrelations of all study variables are further displayed in Table 2.

Except for PBC, *t*-tests revealed no significant differences in baseline cognitions or socio-demographic variables between participants who were interviewed at follow-up and those who were not (i.e., dropouts). Dropouts displayed slightly lower PBC than participants who were interviewed at follow-up ($t = -2.08$, $p < .001$, $r = .15$). There were no significant differences in dropout rates between the intervention arms, $\chi^2(3, 250) = 2.35$, $p = .504$.

Overall, 84 households (37%) had switched to an arsenic-safe well at follow-up. Regarding psychological factors, at baseline, the participants felt quite positively towards collecting and drinking arsenic-safe water, on average, but found it time-consuming and effortful. The ratings for the injunctive norm were favourable. However, the descriptive norm was low: The households perceived only a few of their extended family or neighbours collecting arsenic-safe water. The PBC ratings indicated that the participants, on average, found it rather difficult to collect safe water. Intentions and commitment to collect arsenic-safe water were low. Overall, changes in psychological constructs from baseline to follow-up were small. Large standard deviations, however, indicated that some participants' cognitions became more favourable towards using arsenic-safe wells, whereas others' cognitions became more antagonistic.

Predicting well-switching with psychological changes

Hierarchical logistic regressions to predict well-switching by the time of the follow-up confirmed all hypotheses (H1a and b; see Table 3). In the first step, changes in attitudes, norms, and PBC significantly increased the −2 log likelihood of the constant-only model to predict well-switching, $\chi^2(5, 226) = 41.62$, $p < .001$. In the second step, changes in behavioural intentions, in turn, significantly contributed to predicting well-switching, $\chi^2(1, 226) = 165.85$, $p < .001$. In the third step, changes in commitment strength, as hypothesized, significantly contributed to predicting well-switching (H1b), $\chi^2(1, 226) = 12.67$, $p < .001$. Increases in commitment strength were strongly predictive of well-switching at follow-up.

Intervention effects on well-switching

As expected, considerable behaviour change differences were observed between the intervention conditions (see Table 1). While in the information-only comparison

Table 1. Descriptive statistics at baseline and follow-up, and changes over time by intervention condition

Time × condition	Use of safe wells[a]	Affective attitude[b]	Instrumental attitude[b]	Injunctive norm[b]	Descriptive norm[b]	PBC[b]	Intention[b]	Commitment[b]
Baseline								
Inf	0 (0)	0.48 (0.31)	0.10 (0.12)	0.65 (0.27)	0.33 (0.24)	−0.77 (0.22)	0.31 (0.33)	0.34 (0.23)
Rem + inf	0 (0)	0.45 (0.24)	0.27 (0.27)	0.68 (0.39)	0.23 (0.19)	−0.44 (0.50)	0.32 (0.28)	0.34 (0.20)
Imp + rem + inf	0 (0)	0.56 (0.28)	0.30 (0.21)	0.51 (0.36)	0.31 (0.17)	−0.53 (0.40)	0.34 (0.32)	0.39 (0.23)
Pub + imp + rem + inf	0 (0)	0.45 (0.30)	0.29 (0.25)	0.46 (0.42)	0.37 (0.25)	−0.42 (0.51)	0.33 (0.29)	0.32 (0.21)
Follow-up								
Inf	4 (12)	0.54 (0.35)	0.17 (0.18)	0.72 (0.12)	0.32 (0.14)	−0.59 (0.41)	0.10 (0.26)	0.28 (0.25)
Rem + inf	23 (29)	0.44 (0.34)	0.33 (0.31)	0.71 (0.16)	0.43 (0.16)	−0.41 (0.55)	0.28 (0.37)	0.33 (0.25)
Imp + rem + inf	29 (41)	0.61 (0.29)	0.31 (0.26)	0.74 (0.20)	0.46 (0.16)	−0.41 (0.47)	0.38 (0.41)	0.49 (0.29)
Pub + imp + rem + inf	28 (65)	0.49 (0.30)	0.42 (0.28)	0.76 (0.17)	0.46 (0.13)	−0.24 (0.54)	0.58 (0.40)	0.60 (0.29)
Change[c]								
Inf	4 (12)	0.06 (0.39)	0.07 (0.22)	0.07 (0.29)	0.00 (0.28)	0.17 (0.40)	−0.20 (0.42)	−0.07 (0.26)
Rem + inf	23 (29)	0.00 (0.44)	0.07 (0.41)	0.03 (0.42)	0.20 (0.23)	0.03 (0.74)	−0.05 (0.49)	−0.01 (0.35)
Imp + rem + inf	29 (41)	0.05 (0.39)	0.01 (0.31)	0.22 (0.37)	0.15 (0.21)	0.12 (0.57)	0.04 (0.50)	0.10 (0.37)
Pub + imp + rem + inf	28 (65)	0.04 (0.44)	0.13 (0.40)	0.29 (0.46)	0.09 (0.26)	0.17 (0.75)	0.25 (0.43)	0.27 (0.34)

Note. Inf = information (n = 34); rem = reminders (n = 79); imp = implementation intentions (n = 70); pub = public commitment (n = 43); PBC = perceived behavioural control.

Scales ranged from 0 to 1 (unipolar items) or from −1 to 1 (bipolar items).

[a]*f* (%).

[b]*M* (*SD*).

[c]Individual baseline values were subtracted from follow-up values.

Table 2. Correlations between well-switching and changes in social cognitions

	Pearson correlations[a]						
Variable	1	2	3	4	5	6	7
1. Well-switching							
2. Affective attitude[b]	**.20****						
3. Instrumental attitude[b]	**.28*****	.01					
4. Injunctive norm[b]	**.18****	**.19****	.04				
5. Descriptive norm[b]	**.17***	.01	.06	−.06			
6. PBC[b]	**.31*****	**.26*****	**.62*****	**.14***	.13		
7. Intention[b]	**.76*****	**.33*****	**.20****	.09	**.24*****	**.24*****	
8. Commimtent strength[b]	**.67*****	**.47*****	**.14***	**.17****	**.25*****	**.18****	**.78*****

Note. PBC = perceived behavioural control.
[a]Correlations with well-switching (1 = *switched to safe well*, 0 = *did not switch*) are point biserial correlations.
[b]These variables reflect changes in these cognitions from baseline to follow-up.
In bold: All $p < .05$. *$p < .05$, **$p < .01$, ***$p < .001$.

Table 3. Hierarchical logistic regressions to predict well-switching with changes in psychological factors

	Model 1		Model 2		Model 3		
Changes in…	*B*	OR	*B*	OR	*B*	OR	95% CI
Affective attitude	0.85*	2.35	−0.39	0.68	−2.63*	0.07	0.01, 0.56
Instrumental attitude	1.33*	3.78	0.58	1.78	0.01	1.01	0.08, 12.15
Injunctive norm	0.77*	2.17	1.33*	3.78	1.21	3.36	0.094, 11.95
Descriptive norm	1.56*	5.83	1.10	0.33	−1.36	0.26	0.02, 4.22
PBC	0.45	1.57	0.89	2.44	1.67*	5.31	1.16, 24.33
Intention			10.70***	44,207	8.55***	5,169	143, 187,130
Commitment					5.57**	262	8.6, 7,979
Constant	−1.10*	0.33	−2.06	0.13	−2.53***	0.08	
Nagelkerke R^2	0.23		0.82		0.85		
% Correct	70.8		91.6		92.5		

Note. PBC = perceived behavioural control; CI = confidence interval.
$N = 226$; At T1, all participants were non-users of arsenic-safe wells. Use of arsenic-safe wells at T2 was coded '1' (non-use = 0).
*$p < .05$; **$p < .01$; ***$p < .001$.

condition 12% of the participants had switched, 65% had switched in the condition where all the theory-based BCTs were added (pub + imp + rem + inf). The results of the logistic regressions of the behaviour change effects of the interventions revealed that the information-plus-BCTs condition imp + rem + inf significantly increased the behaviour change effects of the information comparison condition (41% switched; $B = 1.67$, $SE = 0.59$, $p = .004$). The effect was even stronger in the pub + imp + rem + inf condition (65% switched; $B = 2.64$, $SE = 0.62$, $p < .000$). The addition of reminders (rem + inf) also increased the behaviour change effects of the intervention, but this effect was only marginally significant (29% switched; $B = 1.13$, $SE = 0.59$, $p = .055$). All intervention effects were independent of participants' literacy.

Mode of operation of the theory-based BCTs: Mediation analysis

Table 4 shows the results of simple mediation models to investigate the mechanisms of behaviour change promoted by the theory-based BCTs.

Supporting hypothesis H3a, the increased behaviour change effects of the theory-based BCTs targeting commitment strength were significantly mediated by changes in commitment strength for the imp + rem + inf condition. The indirect effect was even stronger for the pub + imp + rem + inf condition. However, the information-plus-BCTs condition with reminders and information alone (rem + inf) only had a small and insignificant effect on changes in commitment strength. The indirect effect was not

Table 4. Simple mediation models to test whether the mediators of the theory-based behaviour change techniques' increased effects on well-switching

	Intervention			Well-switching[a]			Indirect effects (90% CI)		
Mediator × condition	*B*	*SE*	*p*	*B*	*SE*	*p*	LL	*B*	UL
Affective attitude									
Rem + inf	−0.08	0.09	.430	1.85	0.61	.003	−0.46	−0.13	0.13
Imp + rem + inf	−0.00	0.08	.972	0.30	0.57	.596	−0.10	−0.00	0.08
Pub + imp + rem + inf	−0.02	0.10	.849	1.52	0.70	.029	−0.33	−0.03	0.23
Instrumental attitude									
Rem + inf	−0.00	0.08	.964	3.63	0.89	<.001	−0.41	−0.01	0.36
Imp + rem + inf	−0.06	0.06	.309	1.79	0.80	.026	−0.41	−0.11	0.02
Pub + imp + rem + inf	0.06	0.08	.472	0.88	0.79	.264	−0.03	0.05	0.36
Injunctive norm									
Rem + inf	−0.04	0.08	.630	0.01	0.56	.979	−0.08	−0.00	0.08
Imp + rem + inf	0.16	0.07	.033	1.61	0.66	.015	**0.06**	**0.26**	**0.61**
Pub + imp + rem + inf	0.23	0.09	.016	0.32	0.66	.627	−0.19	0.07	0.44
Descriptive norm									
Rem + inf	0.21	0.04	<.001	1.07	0.95	.256	−0.11	0.22	0.68
Imp + rem + inf	0.16	0.05	.002	2.06	1.05	.050	**0.05**	**0.32**	**0.83**
Pub + imp + rem + inf	0.09	0.06	.137	0.39	1.03	.704	−0.11	0.04	0.33
Perceived behavioural control									
Rem + inf	−0.15	0.14	.280	1.71	0.44	<.001	−0.65	−0.25	0.04
Imp + rem + inf	−0.06	0.11	.610	0.78	0.42	.065	−0.30	−0.04	0.05
Pub + imp + rem + inf	−0.00	0.14	.997	1.18	0.48	.014	−0.30	−0.00	0.30
Intention									
Rem + inf	0.15	0.10	.108	9.33	2.28	<.001	−0.21	1.44	6.97
Imp + rem + inf	0.24	0.10	.019	12.20	2.98	<.001	**0.88**	**2.90**	**5.74**
Pub + imp + rem + inf	0.45	0.10	<.001	15.98	4.81	<.001	**3.65**	**7.23**	**14.75**
Commitment									
Rem + inf	0.06	0.07	.399	7.35	1.56	<.001	−0.35	0.42	1.29
Imp + rem + inf	0.17	0.07	.018	6.40	1.28	<.001	**0.37**	**1.11**	**2.15**
Pub + imp + rem + inf	0.35	0.07	<.001	4.49	1.22	<.001	**0.74**	**1.57**	**2.88**

Note. Inf = information (n = 34); rem = reminders (n = 79); imp = implementation intentions (n = 70); pub = public commitment (n = 43); *B* = unstandardized regression coefficients from linear regressions (column 'Intervention') or logistic regressions (column 'Well-switching'); *SE* = standard error; CI = confidence interval; LL = lower limit; UL = upper limit.

Intervention was coded '1', and information-only control was coded '0'. Indirect effects were calculated by bootstrapping (bold: Significant effects).

[a]Effect of potential mediator on well-switching when the intervention effect was controlled for.

significant. Unexpectedly, behavioural intentions significantly increased in the imp + rem + inf and the pub + imp + rem + inf conditions. In similarity to the commitment effects, the indirect effects of the interventions on behaviour change were significant for these conditions, but stronger than for changes in commitment.

Further unforeseen was the significant effect of rem + inf on changes in descriptive norms, although the indirect effect was insignificant. Unexpected additional indirect effects were found for the imp + rem + inf condition: Changes in descriptive and injunctive norms mediated the increased behaviour change effects. The information-plus-BCTs intervention with all three theory-based BCTs (pub + imp + rem + inf) had a medium effect on increasing injunctive norms and a small, insignificant effect on increasing descriptive norms. However, hypotheses H3b and H3c were not supported, as the indirect effects were small and not significant.

Multiple mediation models with the significant mediators from the simple mediation analyses indicated changes in intentions as the only significant mediator of the intervention effects on well-switching for the imp + rem + inf (indirect effect of changes in intentions [CI]: 2.77 [0.23, 5.33]) and the pub + imp + rem + inf interventions (indirect effect of changes in intentions [CI]: 7.29 [3.43, 13.93]). A multiple mediator model for rem + inf was not computed because the simple models did not reveal significant mediators.

Discussion

This study investigated the importance of commitment strength in the behaviour change process. To examine this, theory-based BCTs targeted at increasing commitment strength were added to an information-only intervention to change safe water consumption. As expected, the TPB variables successfully predicted well-switching. This is in line with previous research on safe water consumption (Altherr *et al.*, 2008; Kraemer & Mosler, 2012) and other health behaviours (Fishbein & Ajzen, 2010). Changes in commitment strength increased the power of the TPB and emerged as the strongest predictor of well-switching besides behavioural intentions. Theory-based BCTs targeted at increasing commitment strength (public self-commitment, implementation intentions, and reminders), when added to a promoter-delivered informational intervention, yielded superior behaviour change effects in comparison with information alone, particularly when public self-commitment, implementation intentions, and reminders were combined. The added theory-based BCTs, as hypothesized, promoted well-switching by increasing commitment strength. However, the mediating effect of commitment strength did not emerge when intentions were considered simultaneously. Still, overall, the findings indicate the importance of commitment in the behaviour change process.

Enhancing safe water consumption with theory-based BCTs

The augmentation of an informational intervention with theory-based BCTs proved very useful to enhance well-switching. Even simple reminders increased the behaviour change effects of information by almost 20%. The combined intervention increased well-switching rates by more than 50%. These results are in line with the finding that raising awareness alone has limited effects on increasing safe water consumption (Hoque *et al.*, 2004; Opar *et al.*, 2007), and they extend the research on the effectiveness of implementation intentions to another health behaviour. The effects are particularly encouraging for further application in developing countries, due to their simplicity and low cost – a

maximum of 2 USD per household in the overall intervention condition. What is more, the interventions proved effective for both literate and illiterate participants. However, it is vital to ascertain the sustainability of the behaviour change. What must also be considered is the large dropout rate in the public self-commitment condition. While the promoters' household visits reached most of the participants, almost two-thirds of the participants did not attend the public self-commitment sessions. This must be taken into account when selecting this BCT for interventions. Furthermore, a possible dropout bias for the group with public self-commitment may have led to an overestimation of the behaviour change effect of this BCT.

Mechanisms of theory-based BCTs: The role of commitment strength and behavioural intentions

As expected, the theory-based BCTs induced increased behaviour change by increasing commitment strength. Neither affective or instrumental attitudes nor PBC were modified by the BCTs, which again is in accordance with the theoretical framework that assumes the interventions to operate at a post-intentional level. Most variations in the intervention also increased the subjective and descriptive norms. However, contrary to the assumptions, the changes in these factors were only found in the mediation analyses for the group with implementation intentions, reminders, and information. Unexpectedly, the information-plus-BCTs interventions that included implementation intentions or public self-commitment increased behavioural intentions. This finding is astonishing, because it was assumed that these BCTs operate at a post-intentional level. One possible explanation for this is reverse causality: The interventions increased commitment strength, which promoted behaviour change. Consequently, both the increased commitment strength and safe water consumption, in turn, may have promoted increases in behavioural intentions. Finally, contrary to the assumption, reminders were not sufficient to elicit commitment change. As outlined in the Introduction, reminders are only assumed to enhance commitment when individuals interpret them as requests to commit (Tobias, 2009). In this study, the reminders were installed by the health promoters and not by the participants themselves. Therefore, it is likely that most participants did not interpret the reminders as a request. Future studies should compare the commitment changes of individuals who install reminders themselves with individuals whose reminders are installed by others.

Limitations and perspectives

One shortcoming of the present study is the small and unequal sample sizes. The small number of participants in the information-only comparison arm in particular may have decreased the power to detect significant results. The number of participants in this group was smaller, because there were no further villages that met inclusion criteria adjacent to this area. Future studies should therefore recruit more participants by selecting larger survey areas.

This study uncovered how public self-commitment and implementation intentions change behaviour when combined with reminders and information. However, combining the different BCTs made it impossible to completely disentangle the effects of the BCTs. For example, the results do not allow the interpretation that commitment is elicited by implementation intentions alone or whether it is a requirement that they are implemented in combination with reminders and information. Future studies should also consider

additional potentially important post-intentional mediators of the BCTs. For example, it would be interesting to investigate whether the construct 'action planning', the extent of how detailed participants perceive the formed plans (Schwarzer, 2008), mediates the behaviour change effects of the BCTs. Furthermore, it may be of interest to explore the impact of the quality of people's plans on the commitment strength–behaviour relation, for example, whether more elaborate plans have stronger impacts. More importantly, it would be interesting to investigate the relation between planning and commitment strength. A research question could be whether more detailed plans follow stronger commitment or whether planning leads to increased commitment to carry out a change in behaviour.

Conclusion

Commitment strength emerged as an important factor for changing safe water consumption and is likely relevant for other health behaviours as well. Therefore, the researchers hope that this study will spark further investigations into the role of commitment in health behaviour change.

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