Achieving long-term use of solar water disinfection in Zimbabwe

H.-J. Mosler a, S.M. Kraemer b, R.B. Johnston*

Eawag, Swiss Federal Institute for Aquatic Science and Technology, Überlandstrasse 133, 8600 Zürich, Switzerland

Article history:
Received 3 August 2011
Received in revised form 17 June 2012
Accepted 3 September 2012
Available online 6 December 2012

Keywords:
Behavioural change
Household water treatment and safe storage (HWTS)
Solar disinfection (SODIS)
Zimbabwe

Introduction

There is compelling evidence that household water treatment can reduce pathogen levels in drinking water and lead to lower reported rates of diarrhoeal disease, even in the absence of sanitation or hygiene improvements.1,2 Household water treatment and safe storage (HWTS) systems can be inexpensive, making them highly cost-competitive compared to...
construction of improved water supplies. Similarly, WHO, UNICEF, and others have increased efforts to scale up the promotion of HWTS in recent years.

However, the reported health impacts have been challenged due to the strong possibility of respondent bias, which can lead to inaccurate reporting of treatment practices and diarrhoeal disease prevalence. This challenge applies to measuring behaviours as well as health impacts: the discrepancy between self-reported behaviour and actual practice is well known in many fields, including handwashing with soap as well as household water treatment.

Even if robust indicators indicate that an intervention has led to household water treatment and improved health, there is little evidence about the long-term sustainability of such gains, especially if subsidized or free material was provided during promotional phases. Some evidence suggests that improvements may be ephemeral. In Pakistan, an intensive intervention led to a dramatic increase in handwashing with soap, and a sharp reduction in both diarrhoea and respiratory disease. However, a follow-up study 18 months after the intervention ended found higher levels of knowledge in intervention households, but no difference in soap consumption or diarrhoeal disease. An evaluation of a combined water treatment/handwashing intervention in Guatemala, made 6 months after the end of the intervention, found no difference in self-reported diarrhoeal prevalence, though intervention households were slightly more likely to practice household water treatment (boiling or solar disinfection).

Adoption of an HWTS system is a process of behavioural change which has to be induced with interventions which target behavioural factors. Mosler describes in his RANAS Model (Risk, Attitudes, Norms, Abilities, and Self-Regulation) the relevant behavioural factors and their correspondent behaviour change techniques (interventions). The RANAS factors have been used to explain behaviour regarding consumption of safe drinking water in several cross-sectional studies. While many studies investigate behavioural change, few ground interpretation of behavioural change in psychological theory, or compare the relative power of different interventions and communication channels. In this manuscript, we use the RANAS framework to analyse the impact of different behavioural interventions combined with different interpersonal communication channels upon uptake of a household water treatment system (solar disinfection, SODIS) in peri-urban settlements of Zimbabwe. Behavioural interventions were made in series, with repeated measurements of SODIS use by households, in order to measure the impact of different interventions, as well as long-term effects of behaviour change. In order to address the potential of respondent bias in self-reported compliance, we assess three alternative indicators of SODIS use.

**Methods**

**Research area**

Field research was carried out in Epworth township and Hopley farm, two peri-urban settlements near Harare, Zimbabwe. Sanitation and hygiene practices in these areas are poor, and most people drink untreated water which is microbiologically contaminated.

From these two settlements, five geographically separated clusters were identified and 878 households selected for interviews: 364 households in two clusters (numbers 1 and 2) from Hopley Farm, and 514 households in three clusters (numbers 3–5) from Epworth. Households were chosen by means of systematic route sampling, in which interviewers went to every third household on their way through their...
assigned area. In all cases, the survey respondent was the person responsible for the drinking water of the members of the household, and gave informed consent prior to the interview.

Interventions

A variety of interventions were made to improve different psychological factors related to uptake and sustainable use of SODIS. In total, six different forms of interventions have been tested in different areas in several combinations. A series of four separate intervention phases were implemented, each followed by a panel survey to assess effectiveness (see Fig. 1). Each panel survey was used to choose an appropriate next intervention for each area, depending on which psychological factors were least positive. Different sequences of interventions were made in each area, with area 5 used as a control area. However, after the last panel, those interventions which proved most useful (e.g. household promotion) were employed for two months in area 5, to ensure fairness.

Baseline survey & information events
SODIS information events were held in all five areas in April 2007. In all areas, bottle centres were established and run by trained SODIS promoters, who sell (used) plastic bottles and inform buyers about SODIS. Though any kind of transparent plastic bottle can be used for SODIS, the poor availability of bottles in general make the bottle centres a potentially successful business idea.

Intervention 1 (October–November 2007)
Two different interventions were chosen to encourage adoption of SODIS: household visits and a pass-on-task in combination with persuasive arguments. In household visits, trained promoters go from household to household discussing with residents to advocate for an innovation. The pass-on-task is a strategy where community members are selected and trained to perform a task dedicated to their social network. These persons try to convince their neighbours, acquaintances and friends, and encourage them to in turn convince others, generating a "snowball effect". Both interventions can be considered to affect risk perceptions and attitudes, as well as perceptions of injunctive norms. Supposedly, pass-on tasks additionally may influence perceptions of descriptive normative behaviours, because people receive information from other people about something they do (and very likely approve of).

Areas 1 and 2 received information and persuasive communication through household visits done by trained promoters who were inhabitants of the project areas. Visual aids included low-literacy flyers which showed pictures on how to use SODIS and listed its advantages such as health improvements, low cost, and good taste. Households were visited once, or in some cases twice, for approximately 30 min.

Areas 3 and 4 received the same information and persuasive communication delivered by means of a pass-on-task. Promoters visited one in five households in the two areas, providing information about SODIS over 30 min. Household members were then asked to pass on the information to someone else (the "pass-on-task"). They received a token with which they could obtain a transparent plastic bottle for half price at a bottle centre. Whenever someone buys a bottle at the bottle centre, that person is informed about SODIS, given (another) token and asked to pass this token on to someone else and so forth.

Intervention 2 (March 2008)
Following the initial phase of SODIS adoption encouragement, different interventions were implemented to sustain or increase SODIS use.

Prompts and public commitment are memory aiding techniques which are widely and successfully used in environmental psychology for fostering self-regulation and social norms. Both often appear in the form of signs (e.g. stickers, posters, cards) that remind the owner of a certain task.

In Area 1, stickers (prompts) were put up inside the house which showed a person putting up bottles on the roof and

![Fig. 1 – Intervention and survey schedule.](image-url)
new people were recruited in each of the later panels, result-
interviewed. Drop-out was low (usually under 10%) and 100
made after a gap of several months. 878 people were originally
surveys directly followed an intervention period; four were

disease reduction among under-five children was only
overall consumption. Altherr
calculate the percentage that SODIS water constitutes of the
beverages. From these responses, the enumerator could
tative information about their consumption of various kinds of
compared in the present study.

Indicators of SODIS use
The use of any household water treatment is typically difficult
to measure. Therefore, three different indicators are
compared in the present study.

Self-reported practice: Survey respondents were asked: “Are
you doing SODIS?” This question has four possible answers:
(a) I am doing SODIS regularly,(b) I am doing SODIS sometimes
or irregularly, (c) I have tried SODIS but stopped, and (d) I am
not doing SODIS. Those people who answered (a) are classified as
“self-reported users”.

Calculated use of SODIS: Survey respondents gave quantita-
tive information about their consumption of various kinds of
beverages. From these responses, the enumerator could
calculate the percentage that SODIS water constitutes of the
overall consumption. Altherr et al. have shown that diarrhoeal
disease reduction among under-five children was only
realized when the calculated proportional use of treated
drinking water was high.24 Although this metric relies on self-
reported information, it is considered less vulnerable to
respondent bias than self-reported practice.

Observed practice: Interviewers observed the number of
bottles they could find placed in the sun (usually on the roof) of
the household they were visiting and indicated this number in
the questionnaire. Households having bottles on the roof
were considered as “observed users”.

Statistical analysis
All of the following analyses have been conducted with the
statistical program SPSS 19, with the exception of concor-
dance analysis, which was made with Stata 11.0 (Stata
Corporation; College Station, TX, USA).

Results
91% of survey respondents were female. The mean age was 32
(SD = 11.43, 13–86); the mean number of years of education
was 8 (SD = 3.39, 0–16), and the mean monthly household
income was 400,000 Zim$ (about US$ 15 at that time; SD = 654,623, 0–10,000,000). On average, each household has
4.5 members (SD = 1.82, 1–13), including one under-five child
(SD = 0.86, 0–6). On average, people possess one to two bottles
per person and use them daily or every two days. No signifi-
cant differences were noted between intervention and control
areas.

With five geographic areas and nine surveys 45 measures
of reported, calculated and observed SODIS practice were
collected. Of these three indicators, calculated and observed
practice agreed most closely (Lin’s concordance correlation
coefficient = 0.815). The mean difference between calculated
and observed use was 1.3%, with a 95% limit of agreement
ranging from −41% to +39% (See Supplemental information
for details).

Figs. 2–4 show the effectiveness of different interventions in stimulating and maintaining SODIS use, using each of these
indicators. A general linear model was developed for the
percentage of SODIS water consumption, which showed that
the development of SODIS consumption changed significantly
over time in all areas (F = 270.37, p < 0.001). Groups were
significantly different from each other (F = 42.70, p < 0.001),
and Bonferroni post-hoc tests reveal that pair-wise differ-
ces between all areas are significant (p < 0.05), except for
areas 1 and 2, and areas 3 and 5, which do not significantly
differ (p > 0.05). The interaction effect between groups over
time is significant (F = 145.13, p < 0.001), meaning that the
groups are developing differently.

The campaigns that could produce most SODIS users were
those using household promoter visits in combination with
persuasion (intervention 1 in areas 1 and 2). Self-reported and
calculated use was quite similar in these areas, while
observed practice also rose significantly, but after a lag period
of several months (with no intervention).

Memory aids like prompts or public commitment (inter-
vention 2, areas 1 and 2) were useful in maintaining high
numbers of regular users.
Pass-on-tasks in combination with persuasion led to only moderate uptake when existing practice was low (intervention 1, areas 3 and 4), and actually decreased SODIS use when practice was high (intervention 2, area 3; intervention 3, areas 1 and 2). The pass-on-task with competition (intervention 3, area 3) did increase self-reported regular SODIS use, but both calculated and observed usage declined.

The strategy of inducing tension (intervention 2, area 4) immediately increased calculated and observed SODIS use; self-reported use also rose after a lag of several months.

The impact of the implementation intention intervention (intervention 3, area 4) is unclear: self-reported and observed SODIS use dropped after the intervention, while calculated usage rose moderately.

The public crier intervention seemed to maintain SODIS usage where practice was high (albeit with a lag in calculated usage), but had little or negative effect where SODIS practice was low.

Sustained practice, as assessed with the final panel survey after six months with no intervention, was mixed. Self-
reported usage declined in all areas after the gap, most markedly where practice was higher. However, calculated SODIS usage displayed exactly the opposite trend in all areas, while observed practice was mixed.

Discussion

Survey data demonstrate that household visits in combination with persuasion are by far the most successful interventions to establish the use of SODIS. By any of the three metrics, at least 65% of people who received household promotional visits were actively practicing SODIS more than two years after the initial promotion, and six months after the end of all interventions. These rates are significantly higher than other groups which did not receive household promotion. These people might be the early adopters in the sense of Rogers’s concept of diffusion of innovations.23 The combination of pass-on tasks, followed by inducing tension (both of which also made use of household visits by promoters) led to similar increases in SODIS usage, though subsequent drop-off was greater.

Where new practices were established, usage could be maintained at high levels through simple prompts and public commitments or public criers. Household visits require a high level of human resources, which can be readily available for small scale research activities, but scaling up of household visits may be difficult for government agencies or local NGOs with limited human resources. Promotion through government agencies may take more time, but may allow more sustainable application of interventions, at larger scales.24 Future research could investigate the practicality and effectiveness of including different degrees of intensity (e.g. number of household visits) in large-scale interventions by government agencies.

It is notable that in the control group from 10% to 25% of households were found to be SODIS users, using any of the three indicators. This shows that without any special intervention apart from information and follow-up surveys a small amount of people will accept an innovation. These people might be the early adopters in the sense of Rogers’s concept of diffusion of innovations.25 In contrast to other findings, these early adopters did not pass their SODIS practice on, and the proportion of SODIS users in the control group did not increase over time. Nevertheless, the usefulness of the diffusion of innovations approach has been demonstrated for the dissemination of SODIS in Bolivia.27,28

The three different indicators of HWTS adoption showed similar trends over time. This study was not able to determine which indicator was more accurate, but the strong correlation suggests that self-reported SODIS usage is a useful proxy for more labour-intensive indicators such as calculated or observed practice. These measurements differ regarding some practical aspects. Reported SODIS use would be greater than calculated use for people who consider themselves as regular users but perform SODIS only to a small extent and so consume only a small percentage of SODIS water. There also might be persons who consume a high percentage of SODIS water but do it only once a week with many bottles and therefore did not have bottles on the roof when observation took place.

Acknowledgements

Ethical approval

All survey respondents gave informed written consent before participating in the study. Ethical approval has been attained from the Research Council of Zimbabwe (RCZ; permit number 02620).

Funding

The presented research is part of a project entitled “Solar Disinfection of Drinking Water for Use in Developing Countries or in Emergency Situations: SODISWATER”, Contract no: FP6-INCO-CT-2006-031650 from the European Union.

Competing interests

None declared.
REFERENCES


Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.puhe.2012.09.001.