A study of the use and impacts of LifeStraw™ in a settlement camp in southern Gezira, Sudan

Salwa Elsanousi, Samira Abdelrahman, Ibtisam Elshiekh, Magda Elhadi, Ahmed Mohamadani, Ali Habour, Somaia E. ElAmin, Ahmed Elnoury, Elhadi A. Ahmed and Paul R. Hunter

ABSTRACT

This paper reports a study of the LifeStraw™ in El-Masraf camp within Gezira State, Sudan. A total of 647 eligible subjects participated in the study. Two week incidence of diarrhoeal rates were estimated by a community survey some four months before and again four months after provision of the LifeStraw™. In addition counts were kept of people attending at the community clinic with diarrhoea. Compliance rates were good with 86.5% of people saying they always used it and only 3.7% saying they had never used it. In a before implementation survey 15.3% of participants reported diarrhoea in the previous 2 weeks compared with only 2.3% in a survey after implementation. Similarly 58 people presented to the clinic as a new case of diarrhoea in the four months before compared with only six in the four months after implementation. When compared with diarrhoeal attendances at the regional hospital, this was a statistically significant decline in attendances ($p < 0.0001$). The LifeStraw™ is likely to find a role as an adjunct to water quality interventions aimed at the home. However, more research is needed to assess the long-term impact and uptake of these devices before their definitive value can be assessed.

Key words | diarrhoea, filter, Sudan, survey, water

Salwa Elsanousi
Samira Abdelrahman
Magda Elhadi
Department of Community Medicine,
Faculty of Medicine,
University of Gezira,
PO Box 20, WadMedani,
Sudan

Ahmed Mohamadani
Somaia E. ElAmin
Elhadi A. Ahmed
Department of Laboratory Sciences,
Faculty of Medicine,
University of Gezira,
WadMedani, Sudan

Ahmed Elnoury
Population Studies Centre,
University of Gezira,
WadMedani, Sudan

Ibtisam Elshiekh
Ministry of Health Gezira State,
WadMedani, Sudan

Ali Habour
Faculty of Medicine,
University of Gezira,
WadMedani, Sudan

Paul R. Hunter (corresponding author)
School of Medicine Health Policy and Practice,
University of East Anglia,
Norwich NR4 7TJ,
UK
Tel.: +44 (0) 1603 591004
Fax: +44 (0) 1603 593752
E-mail: *paul.hunter@uea.ac.uk*

INTRODUCTION

Globally diarrhoeal diseases are one of the most important causes of mortality and morbidity in developing countries where most of this disease burden falls on the poorest countries and on the youngest citizens of those countries (Lopez *et al.* 2006). In low income countries inadequate drinking water and sanitation are the major preventable causes of diarrhoeal disease (Prüss *et al.* 2002).

Recent years have seen considerable interest in new technologies aimed at reducing the risk of disease from

doi: 10.2166/wh.2009.050

drinking contaminated water, including many so-called point-of-use devices (Sobsey 2002). These point-of-use devices are designed to improve drinking water quality by filtration, disinfection or both. There is good evidence that these point-of-use technologies can have a significant impact on reducing diarrhoeal disease if used correctly (Fewtrell *et al.* 2005; Arnold & Colford 2007; Clasen *et al.* 2007). However, the potential impact on health of high quality water within the home is lost if children and others then drink from contaminated water outside of the home. An additional issue with in-home water treatment technologies is their sustainability. It is all very well demonstrating a beneficial health effect in a controlled trial; however, once the study is complete, people may not be able or willing to purchase replacements. The long term use and acceptability of many point-of-use devices have not been adequately investigated, but there is some evidence that use tails off substantially with time following an intervention.

One technology that has the advantage of being inexpensive (US$3.5 per unit) and easily portable is the LifeStraw™ (http://www.LifeStraw.com) (Vestergaard Frandsen). This is a water filter housed in a tube that is designed to be carried around the neck. Water is sucked through the filter, just like a straw, when the person wants a drink. While passing through the straw, water is filtered to 5 μm and also iodinated. The lifestraw has been shown to remove about 6 log of bacteria and 1.8 to 2 log of viruses (http://www.vestergaard-frandsen.com/ls-p-testresult.pdf). The LifeStraw™ cannot, however, be relied on to remove protozoa such as *Giardia*. The product has a useful life of 700 litres. It is designed and being marketed for use in developing country settings.

This paper reports a study to test the acceptability of the straw in a camp setting and gain some initial data on its potential for reducing diarrhoeal disease.

METHODS

Study area and population

The study area chosen is the El-Masarf camp near Hamad El-Nil inspection office within Gezira State, Sudan. A total of 713 people live at this camp, having moved originally from Darfur province as migrant agricultural workers before eventually settling in the area. This camp was chosen as the inhabitants have no access to safe drinking water or latrines. The source of drinking water is the irrigation canal, near which many people defecate. Residents within the camp were known to suffer from increased risk of diarrhoeal disease. The study was open to all true residents over the age of two years. A true resident was someone who had lived in the camp for at least a year and was expecting to remain living there for the duration of the study. Of the 713 people in the camp, 647 eligible subjects participated in the study. The remaining 66 residents were children under two years who were excluded from the study. This represents 100% participation of eligible residents. The study size was not driven by power calculations, but was rather a convenience sample of everyone in the camp that was willing to take part.

Study design

An initial survey was undertaken in November prior to introduction of the LifeStraw™ to gather baseline demographic data and identify participants suitable for inclusion in the study. As part of this study people were asked whether they had had diarrhoea in the previous two weeks. All subjects who had diarrhoea two weeks prior to the study were investigated, by stool examination if provided and offered treatment if necessary. At this initial survey residents were encouraged to attend the clinic if they suffered diarrhoea for stool sampling and treatment. After this initial survey, subsequent surveillance of diarrhoeal disease was done by recording the number of visits to the local health clinic as a result of diarrhoea. On 14 February, all residents participating in the study were provided with a LifeStraw™ and trained for its use. The clinic-based surveillance continued until the end of the study in mid June. At the end of the study a post intervention survey was performed using the same questionnaire as the preliminary survey but including questions about the use of the straw. The definition of diarrhoea used in the study was that put forward by the World Health Organization (WHO 2006) in the *Handbook IMCI Integrated Management of Childhood Illness*: namely the passage of watery stool on three or more occasions in a 24 hour period.

Control group

Unfortunately, it was not possible to obtain a control population subject to the same level of investigation. A control group within the same camp was not considered appropriate. In part this was because deriving a control group and an intervention group from the same population would have reduced the size and power of the intervention group. Also it was thought that giving the LifeStraw™ to some but not others living within the camp would have been perceived to be divisive. As an indicator of general levels of diarrhoeal illness in the community we used admissions for diarrhoeal disease to Gezira University hospital.

Laboratory techniques

When provided, stool samples were examined macro and microscopically immediately after receipt and then transported on Cary Blair medium to the microbiology laboratory of University of Gezira for culture and sensitivity. Specimens were cultured within 48 h on very selective XLD medium. Non-lactose fermented colonies of were identified using the following tests: oxidase, urease, citrate, KIA and indol test. Motility was examined using the hanging drop technique.

Data management and analysis

Data was compiled and analysed by Statistical Package of Social Sciences version 14 (SPSS™). Analyses were either simple descriptive statistics or chi-squared tests.

Ethical committee approval

Ethical approval for the study was given by the State Ministry of Health ethical committee. Informed consent was obtained from the study subjects before the study began. This consisted of initial meetings with the camp community leaders where the study objectives and methods were explained. The study was also explained verbally to participants and verbal agreement obtained.

RESULTS

Demographic characteristics of the target group

From 134 households in the camp, 647 participants were recruited. Of these 46% were male and 54% female; the age distribution is shown in Table 1. Male cases of diarrhoea outnumbered female by 1.7:1. By the time of the post intervention survey four households (44 individuals) had left the camp and new families settled in the camp. New families were provided with straws and trained in their use but were excluded from the analysis. Hence the total number of people in the post intervention survey was 603. No household had a latrine and general environmental conditions in and around the households were generally poor as were levels of personal hygiene and food safety.

In the initial survey some 99 of the 647 (15.3%, 95% confidence intervals 12.6–18.3%) participants reported diarrhoea in the previous two weeks. The age specific attack rates are shown in Table 1. In the post study survey only 14 of 603 people (2.3%, 95%CI 1.3–3.9%) reported diarrhoea in the previous two weeks. Although this difference was highly significant (uncorrected $X^2 = 63.9$, $p < 0.0001$), given the lack of a control group we would be very cautious about interpretation. The age difference of cases with diarrhoea did not differ between the two surveys. Some 57 of those reporting diarrhoea in the first survey stated that they had sought medical attention for their illness compared with seven in the final survey.

In the first four months of the study 58 people from the camp presented to the clinic as a new case of diarrhoea

Table 1 | Age distribution of population at initial survey with number of reported cases of diarrhoea in previous two weeks and attack rate by age group

Age group	Population	Reported diarrhoea in previous 2 weeks	Age specific attack rate%/2 week
2–5	69	22	31.88
5–14	201	29	42.03
15–24	144	16	23.19
25–34	88	5	7.25
35–44	64	14	20.29
45–54	44	4	5.80
55–64	19	1	1.45
>64	18	8	11.59

while in the last four months (after use of LifeStraw™) there were only six. This is substantially less than would have been predicted from the survey results. For the same time periods there were 824 and 658 children, respectively, attending paediatric outpatients at Gezira University hospital with diarrhoea. Figure 1 shows the number of cases identified by the camp clinical and paediatric outpatients by month and Figure 2 the ratio between them. It is clearly seen that the incidence of diarrhoea declined up to February in both groups, but that the incidence of diarrhoea did not increase again in the latter half of the study in the camp as it did in outpatients. There was a clear drop in cases of diarrhoea presenting to the camp clinic compared with cases presenting to the paediatric outpatient clinic after the introduction of the LifeStraw™ (uncorrected $X^2 = 30.71$; $p < 0.0001$).

Only 27 stool samples were submitted and of these seven were positive for *Giardia lamblia* cysts, two for *Entamoeba histolytica* cysts, four for *Schistosoma mansoni* ova and two for *Taenia saginata* ova on microscopy. Culture yielded six *Shigella* species and one non-typhoidal *Salmonella*.

Concerning the use of the straw in the final survey, 531 (86.5%) people said they always used it, 80 (9.8%) said they were occasional users and 23 (3.7%) had never used it. Among occasional users, reasons given for not using the straw were that 45% just forgot, 30% found it difficult to use and 23% did not like it. There were too few cases of diarrhoea and also too few volunteers admitting they did not use the straw to conduct any meaningful statistical analysis of the association between use or not and diarrhoeal illness.

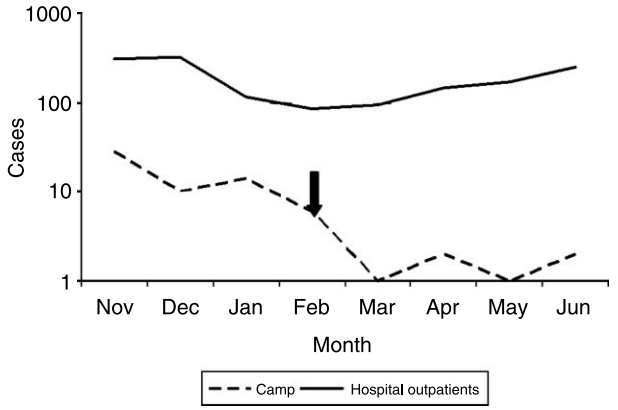

Figure 1 | New cases of diarrhoea presenting to the camp clinic and to paediatric outpatients by month from November 2006 to June 2007 (LifeStraw™ introduced mid-February 2007, as indicated by arrow).

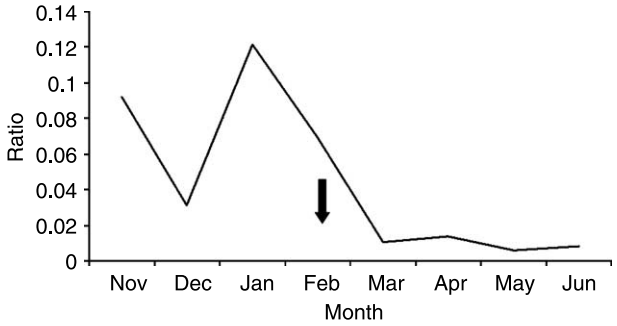

Figure 2 | Ratio of new cases of diarrhoea presenting to the camp clinic and paediatric outpatients by month from November 2006 to June 2007 (LifeStraw™ introduced mid-February 2007, as indicated by arrow).

In post study focus groups most of the people (97%) said they would buy the straw, though 3% did not like it. Most of the people who said they would buy the straw gave as their reason its use to allow them to drink water safely from the canals while working in the field.

DISCUSSION

This is one of the first prospective studies of the use of LifeStraw™ to be reported in the literature. Given the fact that this was not a randomized controlled trial, one has to be cautious about attributing the reduction in diarrhoea observed to the use of the straw. However, the diarrhoeal incidence rates identified at the start of our study are in line with what would be expected from national surveys in Sudan given that under twos (the group with the highest attack rates) were not included in our study (Federal Ministry of Health, Central Bureau of Statistics and United Nations Children's Fund 2001).

The choice of hospital attendances as a control group in this study was not ideal. In general, hospital control groups are problematic in that attendance at hospital is usually influenced by factors that may erroneously be thought to be risk factors for illness. However, we would argue that attendees at the paediatric outpatients' clinic are a reasonable control group in this context. Hospital attendances with diarrhoea are strongly temporally correlated with community diarrhoeal illness rates (Hogan *et al.* 2003).

As such our study does suggest that the use of the LifeStraw™ can lead to a reduction in diarrhoeal disease, as least in the short term. Nevertheless, there is a need for larger scale randomised controlled trials before real benefit of the use of this intervention can be assessed.

What our study has shown is the high compliance rates with the use of the device, at least over the course of this study when these devices were given out for free. It has already been pointed out that one of the problems with studies of point-of-use devices is whether their use continues after the end of the research project (Sobsey 2002). Indeed most trials of such devices including the one reported in this paper have relied on relatively short follow-up periods (Clasen *et al.* 2006*a*). A point also made by Clasen *et al.* (2006*a*) was that many studies did not attempt to measure compliance. Where compliance was measured, most studies reported compliance rates of well below 100% and several less than 50%. Furthermore the impact on diarrhoeal incidence rates was lower in low compliance studies. Compliance rates in this study were good compared with most of the studies reviewed by Clasen *et al.* (2006*a*) with 86.5% claiming they always used the LifeStraw™ and 9.8% saying they were occasional users. It remains to be seen how well used the devices are in future in the camp. However, the portability of the device and its suitability for use while working in the fields was well recognized by the study participants and this should bode well for its subsequent take up.

We would not argue that these devices are the answer to the provision of safe drinking water in the African setting. There remain many issues about point-of-use devices in developing country settings such as their cost and uptake by all sections of the community, not just the wealthiest people. There is also very little data on whether point-of-use devices continue to be used after the initial study period and if so whether they are used appropriately and not used beyond their period of effectiveness. Initial results on the long-term uptake of point-of-use devices are not convincing (Clasen *et al.* 2006*b*; Moser & Mosler 2008). In these authors' opinions, until many of these questions are answered, it would be premature to rely on point-of-use devices as the sole water quality intervention, unless there really is no possibility of central treatment. However, LifeStraw™ may well have a role to play in situations where people and especially children need to drink away from home. As such they could enhance the effectiveness of other home-based water quality interventions, by reducing pathogen exposure through drinking water while away from home. This is certainly the case in the population studied in this work as most of the people are field workers who find it difficult to carry sufficient water with them into the field and have to drink water from the contaminated irrigation canals.

In conclusion we have reported one of the first trials of the use of LifeStraw™ in the peer-reviewed literature. Compliance rates were particularly good and diarrhoeal rates fell after its introduction when compared with hospital attendances with diarrhoea. There is, however, a need for randomized controlled trials before the full effectiveness of the LifeStraw™ can be estimated. However, the LifeStraw™ is likely to have value for communities that work away from home all day and need to drink from surface water sources. As such, the product would be a useful adjunct to other community water interventions.

ACKNOWLEDGEMENTS

This investigation received technical and financial support from the joint WHO Eastern Mediterranean Region (EMRO), Division of Communicable Diseases (DCD) and the WHO Special Programme for Research and Training in Tropical Diseases (TDR).

We also wish to thank Vestergaard Frandsen for the provision of the LifeStraw™, the Ministry of Health Gezira state, Faculty of Medicine University of Gezira, South Gezira locality and the population of the El-Masraf camp.

REFERENCES

Arnold, B. F. & Colford, J. M. 2007 Treating water with chlorine at point-of-use to improve water quality and reduce child diarrhoea in developing countries: a systematic review and meta-analysis. *Am. J. Trop. Med. Hyg.* **76**, 354–364.

Clasen, T., Roberts, I., Rabie, T., Schmidt, W. & Cairncross, S. 2006*a* Interventions to improve water quality for preventing diarrhoea. *Cochrane Database Syst. Rev.* **3**, CD004794.

Clasen, T. F., Brown, J. & Collin, S. M. 2006*b* Preventing diarrhoea with household ceramic water filters: assessment of a pilot project in Bolivia. *Int. J. Environ. Health Res.* **16**, 231–239.

Clasen, T., Schmidt, W., Rabie, T., Roberts, I. & Cairncross, S. 2007 Interventions to improve water quality for preventing diarrhoea: systematic review and meta-analysis. *Br. Med. J.* **334**, 782–785.

Federal Ministry of Health, Central Bureau of Statistics, United Nations Children's Fund 2001 *Multiple Indicator Cluster Survey, 2000. Sudan Final Report*. Federal Ministry of Health, Central Bureau of Statistics, United Nations Children's Fund, Sudan. Available at: http://www.childinfo.org/files/sudan.pdf Accessed 7 March 2009.

Fewtrell, L., Kaufmann, R. B., Kay, D., Enanoria, W., Haller, L. & Colford, J. M. 2005 Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis. *Lancet Infect. Dis.* **5**, 42–52.

Hogan, W. R., Tsui, F. C., Ivanov, O., Gesteland, P. H., Grannis, S., Overhage, J. M., Robinson, J. M. & Wagner, M. M. 2003 Detection of pediatric respiratory and diarrheal outbreaks from sales of over-the-counter electrolyte products. *J. Am. Med. Inform. Assoc.* **10**, 555–562.

Lopez, A. D., Mathers, C. D., Ezzati, M., Jamison, D. T. & Murray, C. J. L. 2006 Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. *Lancet* **367**, 1747–1757.

Moser, S. & Mosler, H.-J. 2008 Differences in influence patterns between groups predicting the adoption of a solar disinfection technology for drinking water in Bolivia. *Soc. Sci. Med.* **67**, 497–504.

Prüss, A., Kay, D., Fewtrell, L. & Bartram, J. 2002 Estimating the burden of disease from water, sanitation and hygiene at a global level. *Environ. Health Perspect.* **110**, 538–542.

Sobsey, M. D. 2002 *Managing Water in the Home: Accelerated Health Gains from Improved Water Supply* [WHO/SDE/WSH/02.07]. World Health Organization, Geneva. Available at: http://www.who.int/water_sanitation_health/dwq/WSH02.07.pdf (accessed 2 December 2008).

World Health Organization 2006 *Handbook IMCI Integrated Management of Childhood Illness*. World Health Organization, Geneva.

First received 9 May 2008; accepted in revised form 1 September 2008. Available online May 2009