Household characteristics associated with home water treatment: an analysis of the Egyptian Demographic and Health Survey

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ABSTRACT

Objectives: The objective of this study is to understand the characteristics of households who treat their water in the home. In promoting home water treatment, there may be valuable lessons to be learnt from countries with many home water treatment users.

Methods: Responses to the new Demographic and Health Survey question on water treatment were analysed for 21,972 Egyptian households interviewed during 2005. Logistic regression was used to assess the relationship between home water treatment and household characteristics.

Results: 5.9% (CI 5.2–6.7%) of households used home water treatment, mostly either home filtration or letting water stand to settle. Filtration use was significantly related to educational attainment and wealth, whilst letting water stand to settle was related to use of stoneware water vessels, groundwater sources, and water supply disruptions.

Discussion: The Egyptian data suggest that 4.5 million people use home water treatment and confirm some water handling behaviours reported elsewhere. Because of limited detail in the DHS data about the technologies used and their effectiveness, it is unclear whether this behaviour reduces waterborne disease. Further research should consider how such data can be augmented with additional information to address this question.

Key words | demographic and health surveys, logistic regression, water purification, water supply

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INTRODUCTION

Diarrhoeal diseases account for 4.3% of the total global disease burden (62.5 million Disability Adjusted Life Years (DALYs)). An estimated 88% of this burden is attributable to unsafe drinking water supply, inadequate sanitation, and poor hygiene (Pruss *et al.* 2002). Target #10 of the Millennium Development Goal (MDG) for water (number 7) is to "Reduce by half the proportion of people without sustainable access to safe drinking water". Following the publication of several systematic reviews (Gundry *et al.* 2004; Fewtrell *et al.* 2005; Clasen *et al.* 2006a, 2007b) of field intervention trials, home water treatment and safe storage (HWTS) is now recognised as a cost-effective means of reducing diarrhoeal disease and meeting this target (Clasen *et al.* 2007a).

However, although HWTS has been proven to reduce diarrhoeal morbidity in small-scale trials, encouraging more widespread use of HWTS among much larger populations is challenging because of scepticism towards new technology (Quick 2003). It is typically easier to encourage households to practice HWTS in small-scale trials, since households are regularly visited by researchers. For example, a follow-up study of South African households targeted through a programme promoting safe water storage via infrequent meetings found no significant change in water storage behaviour (Jagals *et al.* 2004). HWTS interventions are typically supplied at no cost in research studies, whereas some form of cost recovery is often required in larger scale programmes and this has been cited as a barrier to wider uptake (Dunston *et al.* 2001).

In examining the options for scaling up, previous work has focussed on the lessons learnt from large-scale HWTS programmes, and particularly on the effectiveness of the different methods used to promote behaviour change such as motivational interviewing (Thevos *et al.* 2000), community mobilisation and social marketing (Dunston *et al.* 2001; Makutsa *et al.* 2001). However, to be sustainable, the households adopting HWTS under such larger scale programmes need to be able to use home water treatment without continued intervention from government or other agencies.

In parts of the world where home water treatment is already widespread, there may be valuable lessons to be learnt about which technologies prove popular, which sectors of the population use them, and how the technologies are distributed to the population. Demographic and Health Surveys (DHS) have started to include some questions about home water treatment and storage. The DHS are a set of household sample surveys conducted in many developing countries that are designed to be nationally representative. To improve monitoring of progress towards the MDG concerning access to safe water, a question on home water treatment was introduced into the latest phase of DHS surveys (Phase V), beginning in 2005. This enables households who treat their water using recognised technologies to be classified as having access to safe water.

DHS data are available online (http://www.measuredhs.com/) for use by the research and development communities. Results for the 2005 Phase V DHS for Egypt were the first that contained the new question wording to be released for research use in 2006, although the new question wording had been implemented earlier than this in DHS surveys in several other countries. Phase V DHS data sets that include data on home water treatment have subsequently been released for Armenia, Cambodia, Ethiopia, Haiti, Honduras, Nepal, Uganda and Zimbabwe. However, in this paper we use the 2005 Egyptian DHS data to assess the extent of home water treatment usage and the levels of usage among different sectors of the population, since it was the only such data set released at the time we initiated our analysis.

Since the DHS suggests that 98.0% of Egyptian households have access to improved water supplies, Egypt does not on first inspection appear to be a country where drinking water quality is a public health concern. However, there are reasons to believe that Egyptian households may be exposed to microbiologically unsafe drinking water. Many households in the DHS stored water in stoneware vessels. In common with studies elsewhere (Wright *et al.* 2004), several Egyptian studies have reported recontamination of such stored water from improved supplies (El Attar *et al.* 1982; Platenburg & Zaki 1993). Treatment of water for improved supplies may be inadequate. A study of five desalination units in Sharm El-sheikh (Diab 2001), for example, suggested that the desalinated water leaving many of the plants was microbiologically contaminated. Approximately one third of DHS respondents reported interruptions to their water supplies. Such interruptions are known to compromise water quality (Coelho *et al.* 2003), for example as low or negative water pressure draws in contaminated water into piped networks. The DHS also suggests that the prevalence of child diarrhoea in Egypt is comparable with those derived from recent DHS in sub-Saharan Africa with lower improved water source coverage. The prevalence of diarrhoea among Egyptian children under 5 years was 18% (El-Zanaty & Way 2006), a figure comparable to DHS prevalence estimates for Ethiopia, higher than that for Zimbabwe, but lower than that for Uganda.

METHODS

Data

The 2005 Egyptian DHS included responses from 21,972 households drawn from 26 provinces across Egypt. In common with the template followed by such surveys internationally, the Egyptian DHS gathered data on a wide range of topics, including basic household and respondent characteristics, child health, nutritional status and feeding practices, fertility and mortality, family planning, maternal healthcare, HIV/AIDS, knowledge of infectious diseases, and child welfare (El-Zanaty & Way 2006). The majority of the variables gathered within the DHS are collected through questionnaires and depend on accurate recall by household respondents.

Estimating extent of HWTS use

We used Stata 9.0 to calculate the proportion of households using different types of home water treatment. The 2005 Egyptian DHS made use of a multi-stage cluster sample design and we took this into account in calculating proportions using the Stata *svy* and *svyset* commands.

Identifying household characteristics leading to HWTS uptake

The relationship between home water treatment and household characteristics was analysed using logistic regression. To reduce the risk of identifying spurious associations in the DHS data, we restricted our exploration of household characteristics to those that had been posited as affecting HWTS uptake in previous studies. The following variables, which had been found to be associated with HWTS in previous studies, were selected for regression analysis prior to instigating our analysis:

- *Use of a kola/zeer (stoneware water container)*. Previous anthropological research in the Nile river delta (Belasco 1989) has suggested that households there considered the use of *zeers* to be a form of water treatment in its own right. Water is often left to stand in *zeers* as a means of cooling it, as water evaporates out through the vessel sides. Use of such vessels should therefore increase the likelihood of water settlement being reported as a treatment method, but decrease reporting of other water treatment methods.
- *Level of education*. Those with more years of formal education may be more aware of the dangers of unsafe water and more likely to treat their water. A post-implementation evaluation of household use of home chlorination after a promotion campaign in Zambia, for example, found that chlorine use was significantly greater among those with post-secondary education (Olembo *et al.* 2004).
- *Rurality*. Some technologies, such as water filters, may be more easily purchased in urban areas and towns than rural areas. In India, for example, an analysis of 1998–99 National Family Health Survey data suggested 15.2% of households used water filters, compared with only 2.5% in rural areas (McKenzie & Ray 2004).

- *Wealth*. Some technologies may be comparatively costly and only affordable by wealthier households. In poorer communities, for example, fuel for boiling water can account for a significant proportion of household income (Gilman & Skillicorn 1985). The DHS does not measure household income or expenditure, but instead includes a composite wealth index, based on a household's assets (e.g. television, radio, etc.), housing characteristics (e.g. roofing materials, number of rooms), and water and sanitation facilities (Rutstein & Johnson 2004).
- *Type of water source*. Those who believe they have a low quality, unimproved source may be more likely to treat their water. In the Zambian chlorination programme evaluation, households obtaining water from rivers and streams were significantly more likely to chlorinate their water (Olembo *et al.* 2004).
- *Interruption in supply*. Previous work suggests that home water treatment is more widespread among those drinking turbid water (Olembo *et al.* 2004). Those who experience interrupted, improved supplies may see discolouration in their water and may be more likely to treat their drinking water.

We also assessed several potential associations postulated in other studies, but not borne out by previous research:

- *Age of household head*. Younger household heads may be more open to newer HWTS technologies such as chlorination than older household heads, who may rely on more traditional methods. Although this hypothesis appears plausible, previous surveys which have followed up households targeted through home water treatment promotion programmes in Zambia and Kenya have found little evidence to support it (Olembo *et al.* 2004; Parker *et al.* 2006).
- *Disposal of waste*. Those carefully disposing of domestic waste may place greater importance on other hygienic behaviours, such as water treatment, although this is not borne out by previous studies (Olembo *et al.* 2004).
- *Sanitation access*. Those investing in adequate sanitation may be more likely to invest in water treatment technologies. This association has only been indirectly assessed through a composite housing condition index that included sanitation as a component and was found to be significantly related to HWTS (Olembo *et al.* 2004).

- *Cooking facilities*. Cooking on an open fire or stove rather than a gas or electric cooker may make boiling water more time-consuming and difficult (Gadgil 1998).

We did not include access to an electricity supply, on the grounds that almost all households (99.4%) had access to electricity and nearly all home water treatment users had electricity.

The relationship of each variable to HWTS was examined initially through univariate logistic regression. Following recommendations made elsewhere (Mickey & Greenland 1989), we subsequently included all variables significant at the 25% level in a multivariate logistic regression model. Backwards stepwise regression was used to develop a final regression model and all variables in the final model were tested for statistically significant interaction terms. To guard against the selection of confounding or 'noise' variables which are known to be a problem in such analysis, we examined the plausibility of each significant association with HWTS identified in this final model.

RESULTS

How many HWTS users are there in Egypt?

Given that Egypt's population was estimated to be 76.5 million as of the June 2006 census (State Information Service/Central Agency for Public Mobilisation & Statistics 2007), the nationally representative DHS data imply that there were some 4.5 million (CI: 4.0–5.2) home water treatment users in Egypt as a whole. 98.0% of households in the DHS used improved supplies according to WHO's classification. 98.9% (CI: 97.4–99.5%) of those using water treatment had improved supplies. Those using water treatment were very largely using supplies which would be considered microbiologically safe according to the methodology for monitoring progress towards MDG 7 (Gundry et al. 2006).

Only two home water treatment methods–filtration and letting water stand to settle–were in widespread use (Table 1). Consequently, the characteristics of households using home water treatment were investigated for these two technologies only.

Table 1 | Proportion of Egyptian households using different types of home water treatment in 2005

Type of treatment	Percentage of households using treatment (95% confidence limits)
Boiling	0.39 (0.24–0.05)
Adding chlorine/bleach	0.03 (0.00–0.05)
Straining through a cloth	0.28 (0.20–0.36)
Home filtration	2.98 (2.39–3.57)
Solar disinfection	0.02 (0.00–0.05)
Letting stand to settle	2.29 (1.94–2.64)
Other	0.00 (0.00–0.01)
No method	94.04 (93.32–94.75)
Do not know	0.02 (0.00–0.04)

Characteristics of households using home water treatment

Table 2 summarises the relationship between various household characteristics and home water filtration. As only two households using filtration did not have access to an in-house piped water supply, water supply characteristics were dropped from the analysis. Type of fuel used for cooking was dropped from the analysis for the same reason. Use of water filtration was related to wealth, the method of domestic waste disposal, rurality, access to sanitation, and years of education. 10.6% of households in the wealthiest quintile used filters and these households were 18.2 times more likely to use filters than those in the remaining four wealth quintiles. 9.3% of households used filters where at least one member had 15 or more years of education. These households were 8.4 times more likely to use filters than households whose members had fewer years of education. In the multivariate model, however, only wealth and years of education were related to water filter use.

Table 3 summarises the relationship between household characteristics and letting water stand to settle. In the univariate analysis, this behaviour proved to be weakly related to several household characteristics. Those using *kolas/zeers* were 1.5 times more likely to let water settle than those without such vessels. Households not using a stove or open fire for cooking were 2.8 times more likely to let water settle than those that did. Similarly, households which had experienced water supply disruptions in the last fortnight were 2.8 times more likely to let water stand to settle. In the multivariate

Table 2 | Univariate and multivariate logistic regression results, showing relationship between selected household characteristics and use of water filtration in the home

Household characteristic	Unadjusted (univariate) odds ratio (95% confidence limits)	Adjusted (multivariate) odds ratio (95% confidence limits)
Used stoneware vessel (*kola/zeer*) for water storage	0.13 (0.08–0.21)[*]	0.81 (0.50–1.32)
Disposal of domestic waste		
Had domestic waste collected	1.0	1.0
Dumped domestic waste	0.17 (0.11–0.26)[*]	1.09 (0.66–1.77)
Disposed of domestic waste by burning/feeding to animals	0.16 (0.09–0.30)[*]	1.74 (0.92–3.29)
Experienced intermittent water supply	0.99 (0.76–1.28)	n/a
No access to modern flush toilet	0.05 (0.03–0.07)[*]	0.84 (0.49–1.43)
Location		
Rural area	1.0	1.0
Large city	4.11 (2.72–6.20)[*]	1.22 (0.77–1.92)
Small city	1.67 (1.06–2.64)	1.21 (0.77–1.89)
Town	1.00 (0.59–1.68)	n/a
Maximum number of years of education of any household member	1.48 (1.39–1.58)[*]	1.15 (1.09–1.21)[*]
Wealth index	7.92 (6.45–9.73)[*]	5.82 (4.41–7.68)[*]
Age of household head	1.01 (1.00–1.01)	1.00 (0.99–1.01)

[*]indicates significant at the 99% level.

model, use of an improved groundwater source, use of a *kola/zeer*, cooking on a stove or open fire, and experiencing an interrupted water supply were all weakly but significantly related to letting water stand to settle.

Table 4 shows the final fitted logistic regression models for both water filtration and allowing water to settle. Use of a water filter was related to both educational attainment and wealth. The wealthiest 20% of households comprised 85% of those using filters, with virtually no households in the poorest 60% of households using home filtration. Letting water to settle was only weakly predicted by household characteristics, but was significantly greater among those with disrupted water supplies, using improved groundwater sources, and using *kola* or *zeer* vessels to store their water. Those using stoves and open fires were less likely to allow water to settle. Unlike home filtration, use of water settlement was not confined to the wealthiest households.

DISCUSSION

The DHS provides a new source of information on HWTS. The 2005 DHS data for Egypt suggest that there are some 4.5 million individuals using home water treatment in the country. Almost all of the households treating their water used improved supplies and would thus already be considered to have access to safe water in monitoring progress towards the MDGs. The technologies being used in Egypt were largely filtration and letting water stand to settle. In other countries, very different patterns of HWTS use are known to exist. In parts of south Asia such as Sri Lanka, for example, boiling is extensively used to treat water in the home (Mertens *et al.* 1990). The findings presented here are thus likely to be specific to Egypt and unlikely to have wider applicability elsewhere.

The DHS confirms the use of some of the home water treatment and storage technologies described in previous Egyptian studies. In Egypt, water has traditionally been stored in *zeers* (conical stoneware pots), which help cool water as it evaporates through the porous pot material (El Attar *et al.* 1982; Miller 1984). In urban areas of Egypt, these vessels cost between US$1.75 and US$4.39, depending on their size (Mansour 2007). They are also widely available in rural areas. The DHS suggests that such stoneware vessels remain popular with Egyptian households. Even among the poorest quintile of Egyptian households, 37% of households used these stoneware vessels. Anthropological research in the Nile delta (Belasco 1989) found that households there

Table 3 │ Univariate and multivariate logistic regression results, showing relationship between selected household characteristics and water settlement (allowing water to settle during storage in the home)

Household characteristic	Unadjusted (univariate) odds ratio (95% confidence limits)	Adjusted (multivariate) odds ratio (95% confidence limits)
Used stoneware vessel (*kola/zeer*) for water storage	1.35 (1.15–1.81)*	1.36 (1.04–1.79)
Disposal of domestic waste		
Had domestic waste collected	1.0	1.0
Dumped domestic waste	1.22 (0.90–1.65)	1.10 (0.79–1.51)
Disposed of domestic waste by burning/feeding to animals	1.08 (0.76–1.51)	n/a
Experienced intermittent water supply	3.01 (2.34–3.87)*	3.23 (2.54–4.09)*
Sanitation		
Modern flush toilet	1.0	
Other sanitation–merge	1.17 (0.89–1.55)	n/a
Location		
Rural area	1.0	1.0
Large city	0.96 (0.65–1.43)	n/a
Small city	0.69 (0.46–1.04)	0.76 (0.50–1.15)
Town	0.97 (0.53–1.80)	n/a
Maximum years of education of any household member	1.00 (0.98–1.03)	n/a
Wealth index	0.90 (0.81–1.00)	1.01 (0.86–1.19)
Age of household head	1.00 (0.99–101)	n/a
Water supply		
Indoor piped supply	1.0	1.0
Outdoor piped supply	0.61 (0.30–1.23)	0.61 (0.30–1.26)
Improved groundwater	1.56 (0.74–3.30)	2.33 (1.07–5.07)
Unimproved source	0.54 (0.10–2.97)	n/a
Used stove/open fire for cooking	0.34 (0.17–0.70)*	0.26 (0.12–0.57)*

*indicates significant at the 99% level.

Table 4 │ Final multivariate logistic regression models for use of water settlement and home filtration

Household characteristic	Odds ratio (95% confidence limits)
Use of a water filter	
Wealth index	5.88 (4.74–7.30)*
Maximum education level of any household member (no of years of education in excess of 7)	1.15 (1.09–1.21)*
Letting water stand to settle	
Use of an improved groundwater source	2.91 (1.30–6.50)*
Use of a *kola* or *zeer*	1.39 (1.09–1.77)*
Water supply disrupted during last 2 weeks	3.37 (2.65–4.30)*
Used a stove or open fire for cooking	0.25 (0.12–0.53)*
Water supply disrupted AND improved groundwater source (interaction)	0.13 (0.03–0.66)

*indicates significant at the 99% level.

disliked the taste of chlorinated piped water and some used other drinking water sources in preference to piped supplies as a consequence. This may partially account for the minimal use of home water chlorination in the DHS data.

Seeds from *Moringae* species have been reportedly used as a natural coagulant to clarify water in rural areas of neighbouring Sudan (Jahn & Dirar 1979; Folkard *et al.* 1999) and promoted as a 'traditional' water treatment technology. However, even in the southern provinces of Egypt which neighbour Sudan, there was no evidence within the DHS of households using this technology.

The DHS data also reveal some use of home filtration, though the use of water filters was largely confined to the wealthiest 20% of households and more widespread among the better educated. Given that greater HWTS uptake among wealthier and better educated households has been observed in previous studies (Gilman & Skillicorn 1985; Olembo *et al.* 2004), these associations seem plausible. However, the plausibility of some of the household characteristics marginally associated with letting water stand to settle is more questionable. In particular, the greater water settlement usage among improved groundwater source users and slightly lower usage among those with stoves or open fires lack a plausible mechanism and may be due to confounding.

Despite these insights into HWTS uptake, there are some limitations to this new data set. These limitations relate to the possible effects of bias on data quality, on understanding the specific treatment technologies and how households use them, and in gauging the impact of health promotion campaigns.

Although the DHS data sets are designed to be nationally representative, nonetheless, there is debate as to their reliability for public health planning. In particular, the majority of variables included within the DHS data set are questionnaire-based and may be subject to reporting and recall bias (Boerma & Sommerfelt 1993). Analysis of early DHS data found self-reported diarrhoea prevalence derived from the survey to be inconsistent with other national surveys conducted at the same time (Boerma *et al.* 1991). A more recent analysis of DHS data from multiple countries found that morbidity trends were inversely related to mortality trends across provinces and wealth quintiles in many of these countries (Manesh *et al.* 2007). Both of these inconsistencies were primarily attributed to reporting and recall bias in DHS questionnaire data. These biases may also have affected the reporting of the HWTS behaviours described here, although it is not possible to quantify their impact without conducting additional fieldwork.

Whilst it is encouraging that millions of Egyptians are using HWTS, it is difficult to gauge the health impact of this behaviour. Water settlement has been promoted as a HWTS technology (Skinner & Shaw 1998), but there is limited field evidence of its effectiveness in improving microbiological water quality. Similarly, there is some concern that efforts by households to treat their water may be less effective in the absence of hygiene promotion campaigns. A case-control study in Karachi, for example, found only 2 out of 17 samples of stored water filtered by households were free of thermo-tolerant coliforms (Luby *et al.* 2000). In emergency situations, even boiling has been found not to improve the microbiological quality of stored water, as a study of Indonesian tsunami survivors found (Gupta *et al.* 2007).

A particular difficulty in assessing the likely health impact of household use of home filtration is in understanding the filtration technologies being used. Evidence from intervention trials of HWTS using ceramic filters, for example, has been encouraging (Clasen *et al.* 2005, 2006b). Laboratory investigations of commercially available ceramic candle and iodine resin filters in India (Chaudhuri *et al.* 1994; Clasen & Menon 2007) suggests that whilst they can achieve reductions of more than 2 logs in *E. coli* counts, their performance does not meet international standards, unlike the filters that have been used in many intervention trials.

Our analysis does not consider the impact of government-sponsored health promotion campaigns, nor of the pricing and distribution channels for water filters in Egypt. For other behaviours such as contraception, the DHS includes questions about the source of contraceptive devices used (e.g. pharmacy versus hospital) (Oye-Adeniran *et al.* 2005). A similar question for water treatment might improve understanding of the importance of different distribution channels. Other recent studies have used the GPS co-ordinates for sample households to relate DHS data to other spatial databases, notably locations of health services (Hong *et al.* 2006). In future work, it may similarly be possible to relate home water treatment uptake to other spatially referenced data, such as water filter sales by district, or areas targeted by health promotion campaigns.

The DHS does not include data on the prices of filters and so it is not possible here to undertake an economic investigation of household uptake of filters in response to price structure. Even with price data included within the DHS, the insights obtained from analysing DHS price data would not be as great as those from price experiments in the field, such as have been used alongside a home chlorination programme in Zambia (Ashraf et al. 2007).

As more Phase V DHS data become available for other countries, it will be possible to identify which HWTS technologies are popular in those countries and the characteristics of households which use them. Such analyses could act as baseline information for subsequent HWTS promotion campaigns. However, understanding the health impacts of HWTS will be challenging and requires further research into the use and efficacy of HWTS in naturalistic settings. This is particularly true of technologies which produce limited reductions in microbiological contamination, but do not make water microbiologically safe.

CONCLUSIONS

The DHS data suggest that some 4.5 million Egyptians are using home water treatment and this behaviour is taking place without any international effort to promote such technologies. The most favoured treatment technologies are home filtration and allowing water to stand and settle. Use of home filtration was restricted to the wealthiest households in the survey, but water settlement was used by a broader spectrum of households. These findings could be used to inform future campaigns to promote home water treatment, by highlighting the technologies which are already in use in different sectors of the population and building on their popularity.

ACKNOWLEDGEMENTS

REFERENCES

Ashraf, N., Berry, J. & Shapiro, J. 2007 Can higher prices stimulate product use? Evidence from a field experiment in Zambia. Harvard Business School Working Papers1–61. 2007. Harvard University Business School Cambridge, MA, USA.

Belasco, D. B. 1989 Adoption of Community Water Systems: an Area Study in Three Villages in Muhafzat Kofr-Shaykh, Egypt. 1989. Thesis, University of Denver, USA.

Boerma, J. T. & Sommerfelt, A. E. 1993 Demographic and health surveys (DHS): contributions and limitations. World Health Stat. Q. 46(4), 222–226.

Boerma, J. T., Black, R. E., Sommerfelt, A. E., Rutstein, S. O. & Bicego, G. T. 1991 Accuracy and completeness of mothers recall of diarrhea occurrence in preschool-children in demographic and health surveys. Int. J. Epidemiol. 20(4), 1073–1080.

Chaudhuri, M., Verma, S. R. & Gupta, A. 1994 Performance evaluation of ceramic filter candles. J. Environ. Eng.–Asce 120(6), 1646–1651.

Clasen, T. & Menon, S. 2007 Microbiological performance of common water treatment devices for household use in India. Int. J. Environ. Health Res. 17(2), 83–93.

Clasen, T., Parra, G. G., Boisson, S. & Collin, S. 2005 Household-based ceramic water filters for the prevention of diarrhea: a randomized, controlled trial of a pilot program in Colombia. Am. J. Trop. Med. Hyg. 73(4), 790–795.

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

Clasen, T. F., Brown, J. & Collin, S. M. 2006b Preventing diarrhoea with household ceramic water filters: assessment of a pilot project in Bolivia. Int. J. Environ. Health Res. 16(3), 231–239.

Clasen, T., Cairncross, S., Haller, L., Bartram, J. & Walker, D. 2007a Cost-effectiveness of water quality interventions for preventing diarrhoeal disease in developing countries. J. Water Health 5(4), 599–608.

Clasen, T., Schmidt, W. P., Rabie, T., Roberts, I. & Cairncross, S. 2007b Interventions to improve water quality for preventing diarrhoea: systematic review and meta-analysis. BMJ 334(7597), 782.

Coelho, S. T., James, S., Sunna, N., Abu Jaish, A. & Chatila, J. 2003 Controlling water quality in intermittent supply systems. Water Supply 3(1–2), 119–125.

Diab, A. M. 2001 Bacteriological studies on the potability, efficacy and EIA of desalination operations at Sharm El-Sheikh region, Egypt. Egypt. J. Biol. 3, 59–65.

Dunston, C., McAfee, D., Kaiser, R., Rakotoarison, D., Rambeloson, L., Hoang, A. T. & Quick, R. E. 2001 Collaboration, cholera,

and cyclones: a project to improve point-of-use water quality in Madagascar. *Am. J. Public Health* **91**(10), 1574–1576.

El Attar, L., Abdel, G. A., Khairy, A. E. & El Sebaie, O. 1982 The sanitary condition of rural drinking water in a Nile Delta village. II. Bacterial contamination of drinking water in a Nile Delta village. *J. Hyg (Lond)* **88**(1), 63–67.

El-Zanaty, F. & Way, A. 2006 *Egypt Demographic and Health Survey 2005*. Ministry of Health and Population, National Population Council, El-Zanaty and Associate, and ORC Macro, Cairo, Egypt.

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**(1), 42–52.

Folkard, G., Shaw, R. & Sutherland, J. 1999 Water clarification using Moringa oleifera seed coagulant. *Waterlines* **17**, 109–112.

Gadgil, A. 1998 Drinking water in developing countries. *Ann. Rev. Energy Environ.* **23**, 253–286.

Gilman, R. H. & Skillicorn, P. 1985 Boiling of drinking-water: can a fuel-scarce community afford it? *Bull. World Health Organ.* **63**(1), 157–163.

Gundry, S. W., Wright, J. A. & Conroy, R. M. 2004 A systematic review of the health outcomes related to water quality in developing countries. *J. Water Health* **2**(1), 1–13.

Gundry, S., Wright, J., Conroy, R., du Preez, M., Genthe, B., Moyo, S., Mutisi, C., Ndamba, J. & Potgieter, N. 2006 Contamination of drinking water between source and point-of-use in rural households of South Africa and Zimbabwe: implications for monitoring the Millennium Development Goal for water. In *International Water Association. IWA World Water Congress and Exhibition, Beijing, 13-9-2006*. IWA Publishing, London, UK.

Gupta, S. K., Suantio, A., Gray, A., Widyastuti, E., Jain, N., Rolos, R., Hoekstra, R. M. & Quick, R. 2007 Factors associated with E. coli contamination of household drinking water among tsunami and earthquake survivors, Indonesia. *Am. J. Trop. Med. Hyg.* **76**(6), 1158–1162.

Hong, R., Montana, L. & Mishra, V. 2006 Family planning services quality as a determinant of use of IUD in Egypt. *Bmc Health Serv. Res.* **6** doi:10.1186/1472-6963-6-79.

Jagals, P., Nala, N. P., Tsubane, T. J., Moabi, M. & Motaung, K. C. 2004 Measuring changes in water-related health and hygiene practices by developing-community households. *Water Sci. Technol.* **50**(1), 91–97.

Jahn, S. A. & Dirar, H. A. 1979 Studies on natural water coagulants in the Sudan with special reference to Moringa oleifera seeds. *Water SA* **5**(2), 90–97.

Luby, S., Syed, A. H., Atiullah, N., Faizan, M. K. & Fisher-Hoch, S. 2000 Limited effectiveness of home drinking water purification efforts in Karachi, Pakistan. *Int. J. Infect. Dis.* **4**(1), 3–7.

Makutsa, P., Nzaku, K., Ogutu, P., Barasa, P., Ombeki, S., Mwaki, A. & Quick, R. E. 2001 Challenges in implementing a point-of-

use water quality intervention in rural Kenya. *Am. J. Public Health* **91**(10), 1571–1573.

Manesh, A. O., Sheldon, T. A., Pickett, K. E. & Carr-Hill, R. 2007 Accuracy of child morbidity data in demographic and health surveys. *Int. J. Epidemiol.* **37**(1), 194–200.

Mansour, S. 2007 Prices of filters and water vessels in Egypt (personal communication).

McKenzie, D. & Ray, I. 2004 Household water delivery options in urban and rural India. In *5th Annual SCID Conference on Indian Economic Policy Reform*. Stanford Centre for International Development, Palo Alto, CA, USA, pp. 1–57.

Mertens, T. E., Fernando, M. A., Marshall, T. F., Kirkwood, B. R., Cairncross, S. & Radalowicz, A. 1990 Determinants of water quality, availability and use in Kurunegala, Sri Lanka. *Trop. Med. Parasitol.* **41**(1), 89–97.

Mickey, J. & Greenland, S. 1989 A study of the impact of confounder-selection criteria on effect estimation. *Am. J. Epidemiol.* **129**, 125–137.

Miller, F. D. 1984 Problems of water storage in the rural village home: the Egyptian zir. *J. Trop. Med. Hyg.* **87**(2), 53–59.

Olembo, L., Kaona, F., Tuba, M. & Burnham, G. 2004 *Safe Water Systems: an Evaluation of the Zambia Clorin Program*. Johns Hopkins School of Public Health, Baltimore, MD, USA.

Oye-Adeniran, B. A., Adewole, I. F., Umoh, A. V., Oladokun, A., Gbadegesin, A., Odeyemi, K. A. & Ekanem, E. E. 2005 Sources of contraceptive commodities for users in Nigeria. *Plos Medicine* **2**(11), 1145–1151.

Parker, A. A., Stephenson, R., Riley, P. L., Ombeki, S., Komolleh, C., Sibley, L. & Quick, R. 2006 Sustained high levels of stored drinking water treatment and retention of hand-washing knowledge in rural Kenyan households following a clinic-based intervention. *Epidemiol. Infect.* **134**(5), 1029–1036.

Platenburg, R. & Zaki, M. 1993 Patterens of water quality in rural areas oAssyut Goveernorate, Egypt. *Water Sci. Technol.* **27**(9), 55–65.

Pruss, 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**(5), 537–542.

Quick, R. 2003 Changing community behaviour: experience from three African countries. *Int. J. Environ. Health Res.* **13**(1), S115–S121.

Rutstein, S. O. & Johnson, K. 2004 *The DHS Wealth Index*. ORC Macro. DHS Comparative Reports, Calverton, Maryland, USA.

Skinner, B. & Shaw, R. 1998 Technical brief no. 58: household water treatment I. *Waterlines* **17**(2), 15–18.

State Information Service/Central Agency for Public Mobilisation and Statistics 2007 *Statistical Yearbook 2006*. State Information Service, Cairo.

Thevos, A., Quick, R. & Yanduli, V. 2000 Motivational interviewing enhances the adoption of water disinfection practices in Zambia. *Health Promot. Int.* **15**(3), 207–214.

Wright, J., Gundry, S. & Conroy, R. 2004 Household drinking water in developing countries: a systematic review of microbiological contamination between source and point-of-use. *Trop. Med. Int. Health* **9**(1), 106–117.