PART 3 FINDING OUT MORE

Existing low-cost technologies can save lives today

1) Chlorination – adding chlorine in liquid or tablet form to drinking water stored in a protected container

At doses of a few mg/litre and contact times of about 30 minutes, free chlorine generally inactivates >99.99% of enteric bacteria and viruses, provided water is clear. Chlorine can come a variety of sources, including solid calcium hypochlorite, liquid sodium hypochlorite or NaDCC tablets. Household-level chlorination has been implemented most commonly in combination with safe storage and behaviour change techniques, including social marketing, community mobilization, motivational interviewing, communication, and education.

2) Solar disinfection – exposing water in disposable clear plastic bottles to sunlight for a day, typically on the roof of a house

A combination of heat and ultra-violet radiation from the sun are used to inactivate pathogens present in water. One low-cost technique involves exposing water in clear plastic bottles to sunlight for six hours, for example on the roof of a house (or for 2 days if the sun is obscured by clouds). The water should be consumed directly from the bottle or transferred to a clean glass. To be effective, solar disinfection must be applied to relatively clear water.

3) Filtration

Water filtration is another option to purify water. Higher quality ceramic filters with small pores, often coated with silver to control bacterial growth, have been shown to be effective at removing many microbes and other suspended solids. Filters need to be cleaned regularly to maintain flow rates. If properly maintained, they have a long life. Ceramic filters can be mass-produced centrally or manufactured locally in smaller batches. Some commercial systems that combine filtration and disinfection have also been shown to be safe and effective, though their up-front cost may be an obstacle to low-income populations.

4) Combined flocculation/disinfection systems – adding powders or tablets to coagulate and flocculate sediments in water followed by a timed release of disinfectant

These are typically formulated to coagulate and flocculate sediments in water followed by a timed release of chlorine. These typically treat 10-15 litres of water, and are particularly useful for treating turbid water. The water is normally stirred for few minutes, strained to separate the flocculant, and then allowed to stand for another half hour for complete disinfection.

5) Boiling

If practical, households can disinfect their drinking water by bringing it to a rolling boil, which will kill pathogens effectively. In order to be effective, however, the treated water must be protected from re-contamination. Caution must also be exercised to avoid scalding accidents, especially among young children. While boiling is widely practiced, it may be more costly, inconvenient and environmentally unsustainable than other emerging POU water treatment options.

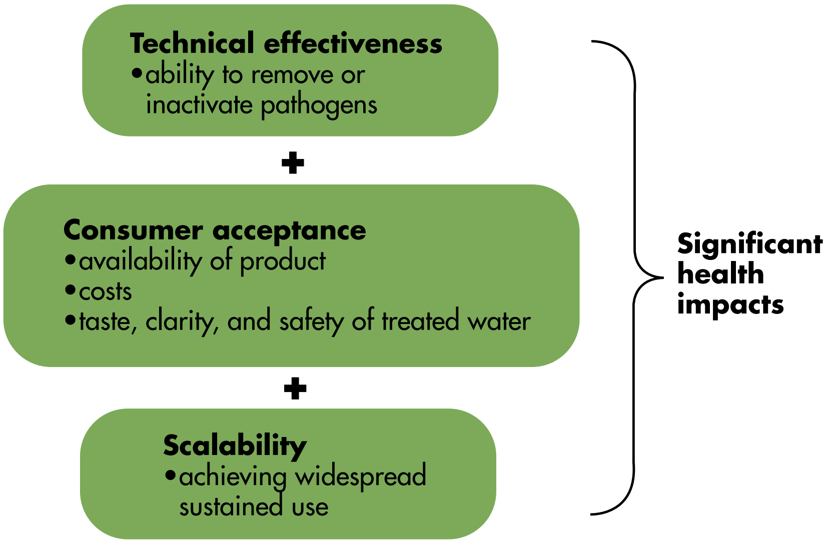
6) Safe Storage

Research has shown that water that is safe at the point of collection is often subject to faecal contamination during collection, transport and use in the home, mainly by unclean hands. Studies have also shown that vessels with narrow mouths and taps can significantly reduce such contamination and reduce the risk of diarrhoeal disease. Where possible, safe storage should also be incorporated included in interventions to treat water in the home.

Different technologies are better suited for different situations. Solar disinfection, for example, may be especially suited for very poor households in sunny regions that draw relatively clear water. Combined flocculation/disinfection systems are a suitable option for treating turbid surface water. Filters have higher-up front costs, but are straightforward to use, and may not require the same degree of behaviour change efforts as other approaches. Household chlorination has achieved widespread use, is appropriate for the very poor, and after boiling is the most common treatment approach.

Achieving Health Gains

A technology must pass three tests for it to achieve significant health impacts:



Frequently asked questions and answers

What is Household Water Treatment and Safe Storage (HWTS)?

HWTS includes a wide array of treatment and storage techniques that are applied primarily at the point-of-use. Examples of household water treatment include boiling, filtration, chemical, solar and UV lamp disinfection, flocculation for the removal of turbidity, and other techniques. Safe storage refers to techniques that minimize the risk of recontamination, including the use of narrow-mouth, screened, and covered containers, as well as dispensing devices such as taps or spigots. Safe storage is a key component of household water management because improper storage can allow recontamination of stored water by microbial pathogens and other contaminants, nullifying the benefits of effective treatment.

Why implement HWTS measures instead of focusing exclusively on infrastructure improvements?

Promoting HWTS and improving water infrastructure are a complementary, not alternative, means to reduce waterborne disease. Infrastructure investment to ensure the safety of improved water supply is essential. The ultimate goal is to provide every family with a safe household connection. However, the high front-end capital costs and long time frame associated with implementing centralized treatment and distribution may exclude many communities, particularly in poor rural areas, from the health benefits of a piped water source in the immediate future. Meanwhile, "improved" water sources (e.g. piped connections, protected shallow wells etc.) do not necessarily deliver safe water, and where and when they do not, additional water management may be required to ensure safety. HWTS is an additional step that can be taken immediately.

When should a household consider using HWTS?

All households unsure of their water safety should consider using HWTS. The main geographic areas of exposure to disease-causing microbial agents in drinking water are developing countries with failing or absent water treatment infrastructure. However, HWTS is appropriate for vulnerable people in countries at all levels of socio-economic development, particularly in smaller communities. Indeed, a report issued by the US National Academy of Sciences concludes that POU systems may be appropriate in communities of under 500 inhabitants in the United States of America.

How do we know if an HWTS technology "works" – that is, that it is actually producing safe drinking water?

Many low-cost HWTS technologies do not come with clear labels and reliable accreditations attesting to their ability to provide "safe" water. This has led to uncertainty and confusion among consumers and other stakeholders. One obstacle to determining whether a technology works is the absence of consensus international guidelines on HWTS performance. To address this problem, WHO is developing guidelines that will establish microbial reduction benchmarks and propose minimum criteria for protocols to verify HWT system performance.

Until such technology verification answers whether a technology "works" with precision, existing studies demonstrate that a variety of HWT technologies improve water quality and result in significant health benefits. For example, a variety of studies examining the impact of porous ceramic filters, with *E. coli* removal rates of 99-99.9%, show significant reductions in diarrhoeal disease morbidity. Household chlorination and safe storage, solar disinfection, and commercially-produced flocculant/disinfection mixtures are examples of other HWTS approaches shown to reduce diarrhoea significantly. Researchers are currently testing other technologies for health impacts.

All HWT measures should be developed to achieve the highest removal rates across important pathogen groups. Significant reductions of diarrhoeal disease are dependent not only on an HWT measure's ability to kill or remove microbial agents from drinking water, but also on its likelihood of adoption by target beneficiaries over the long-term.

What HWST technology is best?

The "best" technology significantly improves water quality, is available, affordable, and accepted for sustainable use by poor households, and has proven health impact. Consumer preferences, willingness to pay, source water quality, and other factors will dictate which technologies are best suited to local circumstances. Since there is no easy formula that will answer this question, consumers should be given choices.

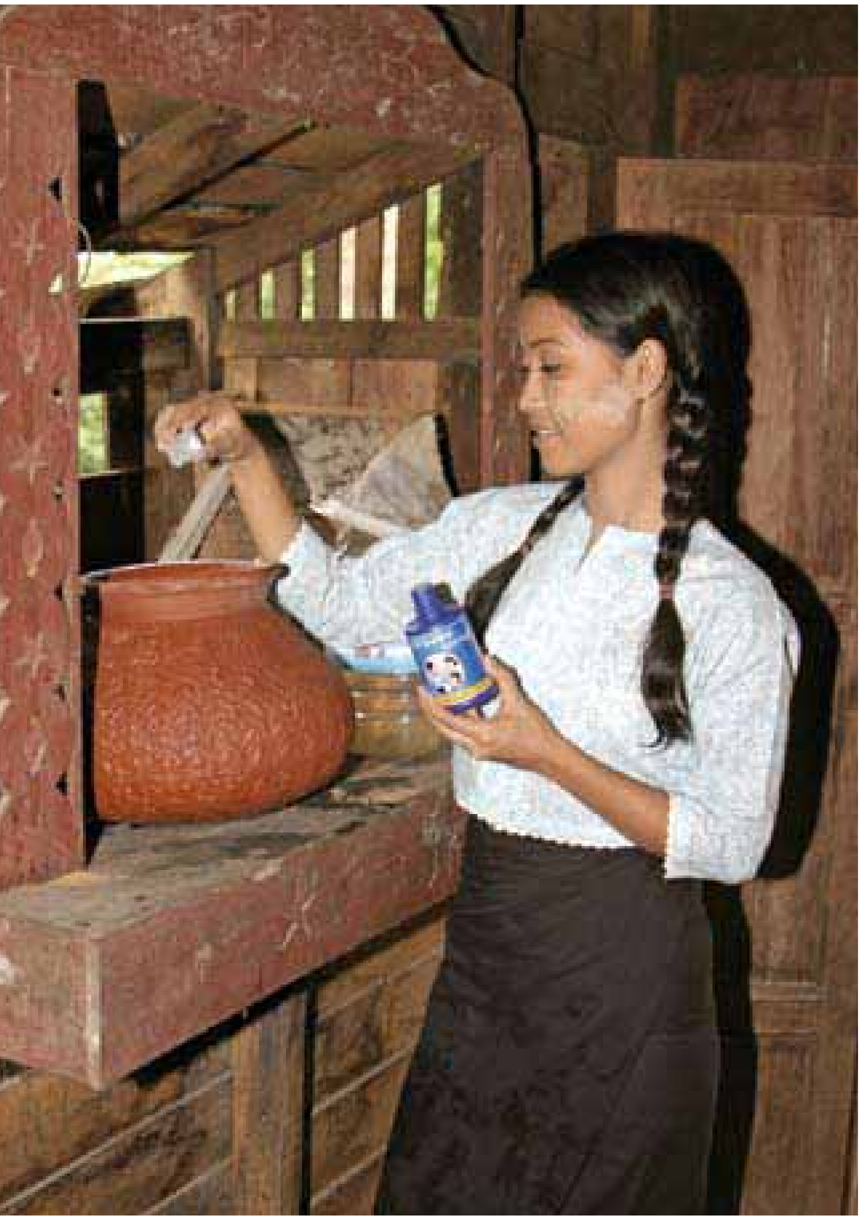
Implementers of treatment devices such as porous ceramic and intermittently-operated household sand filters (biosand filters) have reported relatively high rates of user acceptance. Filters are easy to operate – users simply pour water through the filters. Ceramic filtration in particular has been demonstrated to achieve significant health benefits. At the same time, low rates of virus removal, the absence of residual protection against recontamination, variable treatment capacity, and inconsistent

quality control (in the case of locally-produced units) have been cited as potential weaknesses of the technology. Both porous ceramic and mixed media filtration devices are extremely cost-effective measures over their lifetimes. Poor families can be assisted in paying the front-end capital investments through either subsidies or financing.

Solar disinfection is an example of another measure with proven health impact that requires little capital investment on the part of end-users, and is thus appropriate for the very poor. Additional advantages include water taste being largely unchanged following treatment and minimal risk of recontamination if water is consumed directly from the bottle in which it was treated. Its proper execution relies on significant community education and training whose costs must be borne by implementing organizations. Other limitations of solar disinfection include length of time required to treat water, the limited volume of water that can be treated at once, and the requirement to remove suspended solids before treatment.

Chemical treatment techniques, generally relying on chlorine as a disinfectant, have demonstrated health benefits, are extremely affordable, cost-effective, and significantly reduce microbial pathogen concentrations (with the notable exception of dilute bleach solutions and chlorine tablets against protozoa such as *Cryptosporidium*). Importantly, these techniques leave residual protection against contamination. However, they can leave an odor and taste that some households can find objectionable, and thus can face adoption obstacles among target beneficiaries. Chlorine solutions and tablets are also less effective at treating turbid source water.

Commercially-produced flocculation/disinfection mixtures are very effective at reducing pathogens of all classes (even in turbid waters), have demonstrated health benefits, leave residual protection, and remove muddy sediment as well. Drawbacks include the higher relative costs per litre of water treated.



Furthermore, usage of the treatment process is marginally more complicated than the other measures described above. In deployment of these measures, community education and marketing are essential to achieving sustained adoption.

Boiling is a simple way of killing all classes of microbial pathogens, however large amounts of fuel are required, which make it costly. Furthermore, some users object to a perceived unpleasant taste, which limits acceptability. Boiling can also cause accidents due to the very hot water temperatures and boiled water can become recontamined once it becomes cooled.

Safe storage vessels should be designed to reduce the risk of recontamination, limiting contact between potentially contaminated hands and water. This can be done by using a vessel that has a lid or narrow mouth, and is also fitted with a tap or spigot to withdraw water hygienically.

In short, many HWTS measures have the potential to seriously reduce diarrhoeal disease, and choosing the best measure or suite of measures ought to be driven by a number of factors, a central one being community-articulated preferences.

What constitutes a successful HWTS implementation?

First of all, a successful HWTS implementation should be *effective*, it should reduce incidence of waterborne disease.

Second, it should be *scalable*: initial small-scale pilots that reach a small number of beneficiaries are important, but they are not enough. Truly successful implementations should lead to widespread adoption of HWTS, eventually reaching millions.

Third, a successful HWTS implementation should be *sustainable*: a pilot implementation should necessarily lead to longer term adoption rates that reach increasing numbers of beneficiaries with decreasing requirements for outside funding and programmatic support.

At their most successful, HWTS implementations generate local economic benefits through, for example, the formation of small-scale industries, in addition to health benefits. Self-sustaining projects that, after some period, need no additional donor funding, are ideal. To achieve this, some implementations will require external support in the form of product subsidy or program support in the form of marketing and distribution in their initial stages.

What are keys to successful HWTS implementation?

Achieving sustained and widespread adoption is the major challenge to HWTS implementation. Realizing behaviour change at scale will require solutions tailor-made for specific HWTS measures.

For filtration devices, implemeters need to consider either free distribution or some amount of subsidy or financing to ensure that the capital outlay required does not exclude poor consumers. Ensuring that devices are durable and that maintenance is undemanding (i.e. spare parts are available) are also keys to successful uptake.

Chemical addition measures such as dilute hypochlorite solutions and tablets and flocculant/disinfectant powders require minimal capital investment by the consumer, and are generally distributed in amounts intended to treat much smaller quantities of water than treatment devices such as filters (with regular repeated distributions or sales required). A key challenge associated with these options is the possibility of chemical odor and taste that some beneficiaries may find objectionable. Some socialization is required in these circumstances, and evidence suggests target populations can become accustomed to minimal chlorine residual in their drinking water, just as consumers have in more industrialized economies.

All HWTS measures require some user education to ensure that techniques are properly applied. Solar disinfection, for example, requires that users be trained to array a series of bottles for sun exposure, making sure to wait the required time period before consumption. For flocculation/disinfection powders, a short (5 minute) period of stirring, followed by a filtration through a fabric and a 20-minute waiting period, is often required. The labor associated with these procedures is sometimes perceived as onerous; as such, it has been suggested that user adoption of HWTS measures would be more successful if the labor required for their execution were communicated in contrast to other household work tasks, including other means of obtaining drinking water (such as transporting water to and from distant water supply sources).

Finally, there is evidence that many households are unaware of the health risks associated with drinking contaminated water. Emphasizing the connection between safe water and good health is critical to any HWTS intervention, but other adoption factors (such as price, labor, treatment capacity, taste, odor, and water clarity) may be just as important, depending on context. Meanwhile, there is certainly geographic and cultural variation in community understanding of waterborne disease risks. Women in remote areas of Central Java, Indonesia, for example, demonstrated prior awareness that aluminum salts remove suspended sediment from drinking water. Many vulnerable populations do have awareness of the need for clean water, sanitation, and hygiene, but simply lack access. With that said, education remains a necessary and crucial component of HWTS interventions.

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Photo credits: cover: Karen Kasmauski (home chlorination and safe storage in modified clay pots, Kenya); page 5 WHO/J. Littlewood (Colombia); 7 top to bottom: World Bank/Eric Miller (hospital waiting room, Mozambique), Kasmauski (Kenya), WHO/H. Bower (woman with child on drip due to diarrhoea, health clinic, Afghanistan), Susan Murcott (diarrhoea ward in Homa Bay Hospital, Kenya), Greg Allgood (safe water intervention at village AIDS clinic, Kenya), 8 SANDEC (solar disinfection, India), 9 World Bank/Eric Miller (local hospital, Mozambique); 11 Murcott (Kenya); 12 Greg Allgood (Kenya); 14 Frans Lemmens/Still Pictures (Algeria); 15 clockwise from top: Kathy Bradner (education on care and maintenance of filters, Thailand); Curt Bradner (pressing filters, Thailand), Rob Quick (pottery group with water storage vessels, Kenya); 16 Donna Coveney (health care clinic, Nepal); 17 WHO (collecting water, Mozambique); 18 clockwise from top; UNICEF Nepal (promoting HWTS); Greg Allgood (refugee camp, Sri Lanka), SANDEC (students learning about solar disinfection, Indonesia); left to right, Christine Stauber (water quality analysis Dominican Republic), Greg Allgood (flocculation/disinfection process); 19 Christine Stauber; 21 CDC (Kenya); 23 Daniele Lantagne (water collection in Ethiopia); 24 Liz Wood (demonstrating correct use of ceramic filters, Ghana); 27 Greg Allgood (Morocco); 28 Daniele Lantagne (testing locally made chlorine solution, Haiti); 29 Adriaan Mol (comparing source water to water filtered with a biosand filter, Kenya); 30 PSI Myanmar (disinfecting water at home); 32 Andrew Buller (water filtration, Mozambique); back cover World Bank/Eric Miller (Mozambique).

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Annex

Network Guiding principles

1. The network will use evidence-based approaches with agreed upon standards of effectiveness (e.g. behaviour change, health impact, cost, sustainability) and promote dissemination of information about program approaches.
2. The network will actively involve local people in developing the most appropriate strategies for implementing interventions.
3. The network will recognize the role of women in household management of water and in acceptance and implementation of solutions.
4. The network will operate in a balanced manner in terms of regions, technologies, and types of member organizations involved.
5. The network will promote the use of local technology and resources and local capacity building.
6. The network will maintain an agile structure and administration.

Private-Sector Participation within the Network

NGOs, local governments, communities and other groups have been successful in seeding and supporting household water pilot projects. However, if widespread uptake and sustainability of the interventions are to be achieved, public health and water sectors need to recognize and act on the confluence of interest with the private sector. Using the agreed public health mission of the network, joint public and private-sector action could make greater health gains as it would be fueled by expanded resources, expertise and commitment.

This parallels WHO recognition of the need for open and constructive relations with the private sector and civil society in order to advance its mission.[13] Global public policy networks that link international organizations, governments, non-profit organizations and for-profit corporations to share information and combine resources have been shown to be effective in advocating for common causes, gathering and disseminating knowledge, and building coalitions to address important issues, including health[14].

Membership revocation

Membership may be revoked by WHO from actions including, but not limited to:

1) the improper use of the network name or WHO's name, or any name or reference confusingly similar thereto on any product packaging, sales materials or advertisements, or in any other manner that implies that the network endorses, authorizes or approves of any particular product or service
2) violations of network guiding principles
3) action contrary to the agreed mission of the network

The expulsion process may take place without notice or a hearing. WHO has the authority to interpret whether or not actions on the part of members constitute improper use of the network or WHO's name, violations of guiding principles, or action contrary to the mission of the network, and thus reserves the right to make the final decision on the issue of network membership revocation.

Following written notice of membership revocation, the network Secretariat will remove the member from the Network communications, a website list of collaborating organizations, and ensure the entity is not included on future promotional material or other documents.

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The International Network to Promote Household Water Treatment and Safe Storage

The Network

World Health Organization

The WHO-led Network brings together more than 100 organizations who share its mission of "contributing to a significant reduction in waterborne disease, especially among vulnerable populations, by promoting household water treatment and safe storage as a key component of water, sanitation and hygiene programmes. Participants are currently engaging with decision-makers, actively carrying out research, and implementing projects in more than 60 countries around the globe.