CHOLERA OUTBREAKS AND WASH RESPONSES

THESIS SUBMITTED TO FULFILL THE REQUIREMENTS FOR THE DEGREE OF SPECIALIZED MASTER WASH AT 2IE

Presented by **KABORE Lionnel André Pagnangdé**

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ii. Abstract

Since the first outbreak reported in 1817, cholera has caused thousands of deaths every year. According to the World Health Organization (WHO), up to four million cases are reported each year with up to 143 000 deaths. Water hygiene and sanitation (WASH) interventions are frequently implemented in the field to stop or prevent cholera outbreaks. This document presents the different WASH intervention to stop cholera with their strength and failure and in which context they are more suitable.

Key words: Water, Hygiene, Sanitation, Cholera, Emergency

Résumé:

Depuis le déclanchement de la première épidémie déclarée en 1817, le cholera fait des milliers de morts sur le plan mondial chaque année. D’après l’OMS jusqu’à 4 millions de cas de choléra sont reportés chaque année avec environ 143 000 morts. Des interventions liées au domaine de l’eau de l’hygiène et de l’assainissement sont menées pour stopper ou prévenir le déclanchement d’épidémies de choléra. Ce document passe en revue les différentes méthodes EHA pour stopper le choléra, leurs avantages et inconvénients et les contextes dans lesquels ils sont mieux adaptés.

Mots clefs : Eau, Hygiène, Assainissement, Cholera, Urgence

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iv. Acronyms

AWD: Acute Watery Diarrhea

COAT: Coagglutination Test

FRC: Free residual Chlorine

GTFCC: Global Task Force for Cholera Control

HTH: High Tense Hypochlorite

IP: Institute Pasteur

OCVs: Oral Cholera Vaccines

ORS: Oral Rehydration Solution

RDTs: (Rapid Detection Tests)

SMART: Sensitive Membrane Antigen Rapid Test

SODIS: Solar disinfection

UNICEF: United Nation Children's Fund

VIP: Ventilate Improved Pit

WASH: Water Hygiene and Sanitation

WHO: World Health Organization

I. INTRODUCTION

Cholera is defined as an endemic disease due to contamination water or food by the bacteria Vibrio cholerae. Cholera is one type of diarrheal disease caused by infection of the intestine with the bacterium Vibrio cholerae present in water or food that has been contaminated with fecal matter. In (Colwell 1996) it is stated that the first cholera epidemic occurred in the Middle East and Europe in 1817 and decimated entire communities. In the past cholera has had a high fatality rate which approached 50% in some countries.

In the early 20th century, epidemic cholera was virtually eliminated in industrialized countries through municipal water supply with treatment and sanitation infrastructure. According to ("Progress on Drinking Water and Sanitation 2014 Update | UNICEF Publications | UNICEF" 2015), in 2015, 663 million people still lack improved drinking water sources and 2.4 billion people still lack improved sanitation facilities. Within this inadequate water and sanitation context, cholera transmission continues. According to the World Health Organization ("WHO | Cholera" 2015), in 2014, 190 549 cholera cases with 2231 deaths were reported with a fatality rate of 1.17%. This is a 47% increase compared to 2013. As we can see in Table 1, most of the cholera cases were reported in poor areas, where there is a lack of sanitation and where the access to improved water supply and treatment is still a challenge.

Table 1: Number of cholera cases and death reported to WHO in 2014 ("WHO | WER Archives" 2015)

2014	Number of cases	Number of deaths	Death rate (%)
Africa	104802	1882	1,80
Asia	57165	42	0,07
Hispania	28582	307	1,07
Total	190549	2231	1,17

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The objectives of this study are to determine WASH practices that have been developed or implemented to stop or prevent cholera outbreaks. These methods are compared and then recommendations are made for the use of certain methods in specific contexts.

II. BIBLIOGRAPHIC SYNTHESIS

1. EPIDEMIOLOGY OF CHOLERA

The etymology of the term "cholera" has been in dispute for many years but may provide clues to understanding the disease. For (Colwell 1996) cholera may have been derived from the Greek words, chole (bile) and rein (flow), meaning the flow of bile. Other investigators suggest the name comes from the Greek word cholera, which means gutter of a roof (6). The symptoms of cholera may have suggested to the Greeks the heavy flow of water on roof gutters during thunderstorms.

Knowing the origin of cholera and the route of contamination was a challenge to scientists. In (Glass and Black 1992) the fecal-oral route of transmission of cholera was established by the British physician John Snow and the German physician Robert Koch. They recognized that some agent or poison in human faeces was the etiologic cause of cholera. John Snow identified that the spread of cholera was linked to the drinking of water contaminated by fecal wastes. Robert Koch identified vibrio cholerae in the intestinal content of people who died during cholera outbreaks. The oral route of transmission was confirmed by Rudolf Emmerich, a student of the German chemist and hygienist Max Von Pettenkofer, who swallowed a pure culture of the organism and came down with a severe case of cholera.

Laboratory tests and studies on cholera through the years have led to a better understanding of the epidemiology of cholera. As we can see in (Cholera Working Group et al. 1993) ,Originally it was believed that humans were the only reservoirs of vibrio cholerae but more research has shown that vibrio cholerae has a natural living cycle with a natural reservoir in the environment. Studies of recent cholera outbreaks have identified raw bivalves and undercooked shellfish as important vehicles of transmission in addition to the drinking of unsafe water.

2. VACCINATION

Cholera is a very contagious disease, but can be treated easily and quickly.. Non-WASH solutions were found in the field of preventing cholera outbreaks. These solutions were implemented through the years, mainly in the risky zones. We can learn from (“WHO | WER Archives” 2015) that 90% of those who develop cholera will have a mild or moderately severe illness with diarrhea, which can be treated with Oral Rehydration Solution (ORS) and less than 10% will suffer from moderate to severe dehydration. These cases should be taken to a health facility. Two WHO prequalified Oral Cholera Vaccines (OCVs) named Dukoral and Shanchol are currently available on the international market. The (“WHO | WER Archives” 2015) state that these cholera vaccines were proven effective, safe and well accepted. They are available for people that are at least one year old. For seven days, these vaccines are orally administrated in two doses. Since 1997, more than 4 million doses of WHO prequalified OCVs, have been deployed in mass vaccination campaigns.

The recommendation of the World Health Organization from (“WHO | Prevention and Control of Cholera Outbreaks: WHO Policy and Recommendations” 2015), for the use of OCVs state that:

- OCV should always be used as an additional public health tool and should not replace the usually recommended control measures such as improved water supplies, adequate sanitation and health education. It also needs to be linked to strengthened surveillance and early warning.
- Pre-emptive vaccination campaigns with OCV should be used in areas where the disease is endemic, including during humanitarian crises, as an additional means for cholera prevention and control, but should not replace usually recommended WASH measures. In such settings, vaccination should target high-risk population groups, such as displaced populations in camps with precarious living conditions, underserved populations in resource-poor settings, etc.
- Mass vaccination campaigns may be organized on a reactive basis, as part of the response to a pre-existing cholera outbreak, to reduce mortality and limit the spread of the disease. However, vaccination should not disrupt the provision of other high-priority health interventions to control or prevent cholera. Considering the lack of experience with implementing reactive vaccination against cholera, the feasibility and impact of vaccination in halting on-going outbreaks should be documented and the results widely disseminated.

3. Cholera risk assessment and survey

Around 24 cholera rapid detection tests have been developed for the detection of Vibrio cholerae from diarrheal stool samples. These tests can be evaluated based on the specificity, sensitivity, commercial readiness and their precision in field conditions. According to ("WHO | WER Archives" 2015), few of the rapid detection test such as the Coagglutination Test (COAT), the Institute Pasteur (IP) cholera dipstick, Sensitive Membrane Antigen Rapid Test (SMART) and the Crystal VC dipstick test were found to be efficient. Unfortunately, some of these kits are not in use or have been the subject of very limited studies in the field. Only the Crystal VC dipstick test, an immuno-chromatographic lateral flow device has been widely in use for the detection of cholera either directly from the stools or through the enrichment procedure using alkaline peptone water (APW). This method detects lipopolysaccharide antigens of Vibrion cholera O1 and O139.

According to ("WHO | WER Archives" 2015), reported data from national survey systems are not representative of the reality. Indeed, due to the fear of negative repercussion on tourism and trade, some countries under-report. However, experience shows that to control the spread of cholera, quarantine and embargoes on the movement of people and goods are ineffective.. Instead of putting restrictions on the countries affected by cholera, the neighboring countries should strengthen they own cholera surveillance and preparedness to rapidly detect and face any cholera case. Limitations in surveillance systems, inconsistencies in case definitions and lack of laboratory diagnostic capacities may also contribute to under –as well as over–reporting. During outbreaks, many countries also report as cholera many cases of acute watery diarrhea (AWD) that were not due to Vibrio cholerae, biasing the data

III. MATERIAL AND METHODOLOGY

Using different combination of keys words to know more about our topic we have found lots of articles, scientific review and thesis talking about this worldwide crisis.

These data were collected using search engines such as Google Scholar, HINARI, SSRN, NCBI also from the library of the IRD (Research Institute for Development of Burkina-Faso) and also from public health workers.

The second step was to verify the reliability of the collected information. This was done using inclusions or exclusions criteria. For the web research, the number of citations, the peer reviewed articles, the renowned magazines, and the well-known authors were the targeted sources of information. Our research grid was done in Microsoft Excel to facilitate the compilation of the found information. We have classified our articles in two groups. The first group (class A) regrouped 60% of the findings. In this group, all the articles defined clearly wash interventions to prevent or stop cholera. The second group of articles (Class B) defined interventions not linked to wash, driven to stop cholera. We have found 40% articles in this category.

Table 2: Selection Grid

N°	ARCTICLE (first author and co.)	Publication Date		Key Words	Rank
		< 5 years	> 5 years		
1	Beau De Roc and al.	01/11/2011		treatment, prevention, cholera	B
2	Albert, M.J. and al.		01/08/ 1993	Epidemic, cholera, vibrio cholerae	B
3	Clemens, J.D and al.		01/02/1990	Vaccine, cholera,	B
4	Colwell, Rita R. and al		01/02/2003	Cholera reduction, simple filtration	A
5	Colwell, Rita R.		01/10/1996	Infectious disease,	B
6	Culter, David M. and al		01/05/2004	Public health, improvements	B
7	Conroy, R and al		01/10/2001	Solar disinfection, cholera	A
8	Doocy shannon and al.		01/10/2006	Water treatment, diarrhea reduction, emergency	A
9	Einarsdóttir and al.		23/06/1905	Health education, Cholera	A
10	Fewtrell, lorna and al.		27/06/1905	WASH, cholera reduction	A
11	Guévart Eand al.		30/06/1905	Well disinfection, cholera out break	A
12	Kesola Serette	07/07/1905		Rally against cholera	A
13	Khan, Moslem Uddin and al.		04/06/1905	Wash, cholera, refugee camp	A
14	WHO		15/06/1905	Guideline, cholera control	A
15	Quick, R. E. and al.		May 1996	Water quality, chlorination	A
16	Tanon, A. K.		26/06/1905	Epidemic, cholera, epidemiology	B

The third step was the analysis and the gathering of the collected information. The different articles were summarized, gathered and classify in Microsoft Word as belonging to one category or another.

IV. RESULTS

1. Drinking Water

To prevent or stop cholera outbreaks, simple actions can be implemented to improve the quality of the drinking water. There are many of methods to treat the water at the household level or directly at the source.

a. Household Treatment

There are many household water treatment methods that can be implemented. The choice of the method should be based on criteria such as:

- Effectiveness: How well does the technology perform?
- Appropriateness: How well does the technology fit into people's daily lives?
- Acceptability: What will people think of the technology?
- Cost: What are the costs for the household?
- Implementation**:** What is required to get the technology into people's homes?

Beyond the household water treatment methods, we have:

- ❖ Simple filtration

There are different kinds of filtration, using different methods and having different microbial reduction rates table 3. Another technique is the simple filtration using cloths. The effectiveness of this method has been proved in some areas affected by cholera (Colwell et al. 2003). This study was performed in rural Bangladesh between 1999 and 2002 in 65 villages to control the reduction of cholera due to simple filtration. It demonstrated that "Vibrio choleraee, the etiological agent of epidemic cholera, is commensal to zooplankton, notably copepods. A simple filtration procedure was developed whereby zooplankton, most phytoplankton, and particulates >20 µm were removed from water before use. Effective deployment of this filtration procedure, using just nylon nets or sari clothes, from September 1999 through July 2002 in 65 villages of rural Bangladesh, of which the total population for the entire study comprised ≈133,000 individuals, yielded a 48% reduction in cholera".

Another study in Bangladesh from (Cholera Working Group et al. 1993), confirmed that the filtration method using sari cloths was efficient and sustained by dweller. From the survey data, 31%of 7,233 interviewed respondents reported using a filter of any type and 60% of the filter users reported using cotton sari cloth (either one, two, three, or four layers of cloth). Within the original sari filter group, 74% of the filter users used sari cloth; of the 18% used four layers of sari cloth for filtering, 25% used three layers, 43% used two layers, and 9014% used one layer of cloth. Results of laboratory studies on which the intervention was based had previously shown that two and three layers of sari cloth were effective in removing up to 99% of the attached Vibrio choleraee bacteria.

Table 3: Filtration methods (Sow 2015)

Treatment	Microbial reduction
Rapid granular media	90-99% (if preceded by coagulation/ flocculation)
Slow sand filter	High (>99%)
Ceramic filter	high
Membranes filters	High (depends on microbe and pore size)

❖ Solar disinfection (SODIS)

The SODIS method uses solar radiation and temperature to kill bacteria.

A study by (Conroy et al. 2001) conducted among the Maasai in Kenya evaluated the impact of SODIS using the number of self-reported cholera cases over a three month period following an outbreak. This study was a follow-up to a previous study in which households with children under the age of five had been randomized to SODIS. All previously selected households were visited within six weeks of the outbreak, and local criteria for case definition were used to identify cholera cases. No significant difference in cholera incidence between intervention and control groups was found for those aged over five years. However, the chance of having cholera in children less than five years old was 88% lower in the SODIS group when compared to the control group.

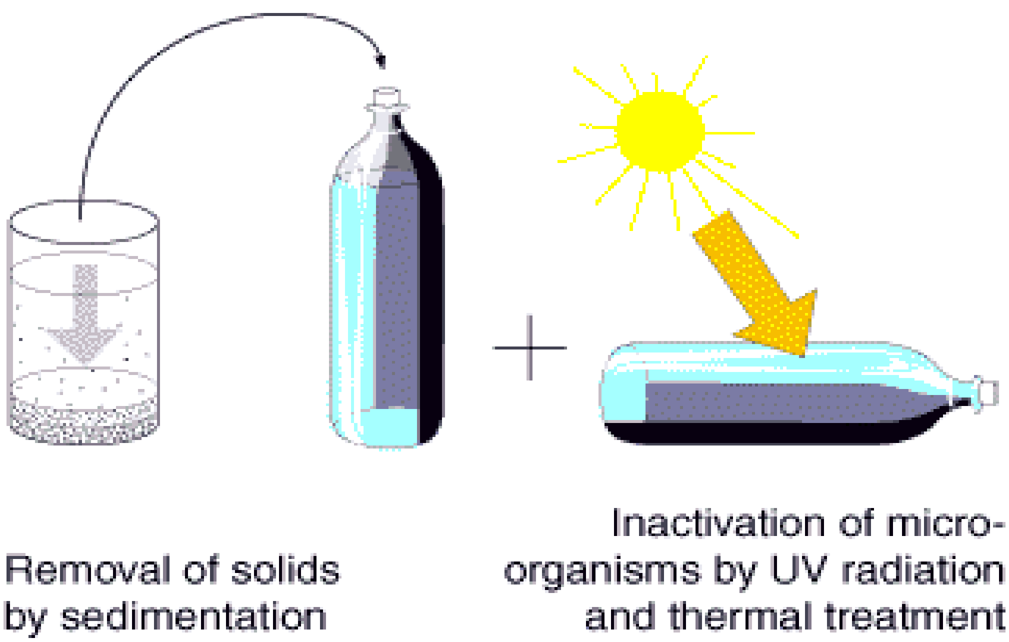

Figure 1: Solar disinfection (Sow 2015)

❖ Chlorination

Summarized from (Taylor et al. 2015).Recent innovations in chlorine-prevention WASH include identification of factors leading to programmatic success, and new product design (such as source based water treatment and personal use sanitation options). An investigation of 14 household treatment program implemented in 4 emergencies (including 3 cholera emergencies) found that reported use ranged from 1% to 93% and effective use (the percentage of recipients who improved their drinking water microbiological quality to international standards) ranged from 0 to 68%. The most successful program provided an effective method (chlorine tablets), with the necessary supplies to use it (bucket and tap), and ongoing training by local community health workers to people using contaminated water who were familiar with chlorination before the emergency. Conversely, the least successful program distributed only chlorine tablets in a relief kit labeled in English to populations without previous chlorination experience.

Similar results were found in an evaluation of dispensers, an innovative source-based intervention that includes a chlorine dispenser and dosing valve installed at water sources, community education, and chlorine refills. Across seven evaluations in four emergencies (including 3 cholera emergencies), reported dispenser use ranged from 9 to97% and effective use from 0 to 81%.

More effective program installed dispensers at point-sources, maintained a high-quality chlorine solution manufacturing and distribution chain, maintained hardware, integrated dispenser projects within larger water program, compensated promoters, had experienced staff, worked with local partners to implement the project, conducted ongoing monitoring, and had a sustainability plan

b. Water treatment at the source

As stated above, the disinfection of water can also be done directly at the source level. There are many methods such as:

❖ Well disinfection

Well disinfection is generally recommended as an emergency response measure during cholera outbreaks.

From ("WHO | Guidelines for Drinking-Water Quality, 2nd Edition" 2015), we have found many techniques that have been developed and tested to treat wells, such as:

- Pot chlorinator and solid chlorine : a pot chlorinator is a pierced container (clay pot, plastic bucket, etc), filled with a chlorine powder and sand/gravel mixture and hung in a well, alone or in a larger pierced container

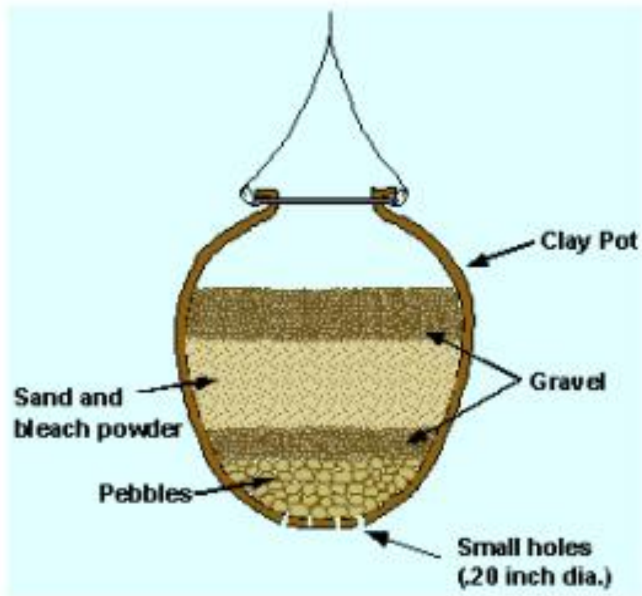

Figure 2: Simple pot chlorination ("Svadlenka Improving Local Water" 2015)

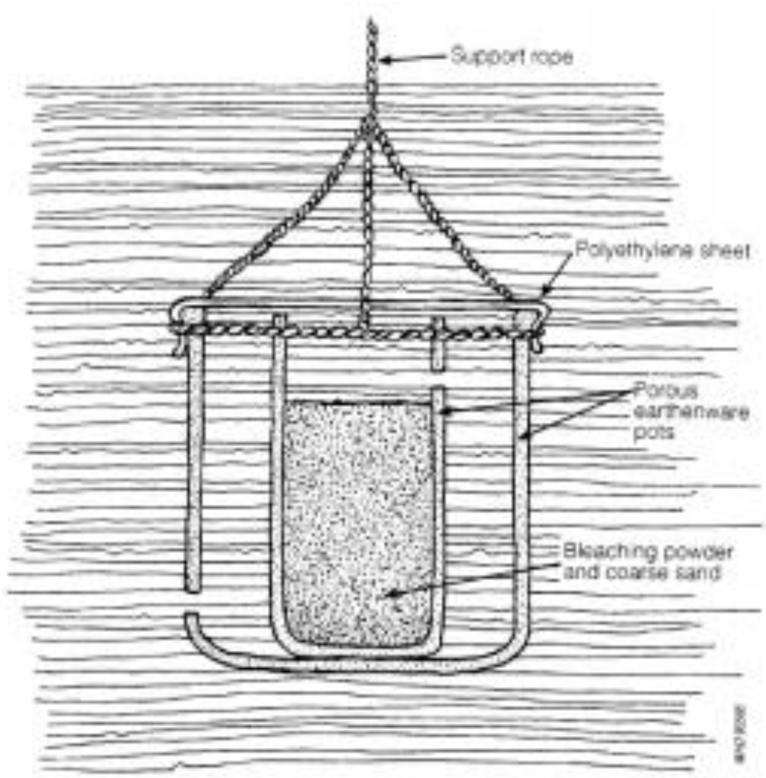

Figure 3: Double pot chlorinator ("WHO | Guidelines for Drinking-Water Quality, 2nd Edition" 2015)

- Injection of liquid bleach: This method usually consists of daily or weekly injections of 1% or 5% bleach in the wells. The doses have being calculated or estimated on the basis of chlorine demand.

Few studies including (Guévart et al. 2008), have been carried out to prove the efficacy of well chlorination, or determine how often disinfection should be performed. The purpose of this study was to test a handmade device for continuous chlorination, to measure the initial concentration of free residual chlorine, and to monitor chlorine concentration to determine when renewal is necessary. Thirty six wells in two neighborhoods of Douala, Cameroon, eighteen wells per neighborhood, were tested. Testing included daily measurement of water volume, pH, and residual chlorine for a period of two weeks after installing the handmade device composed of river sand and hypochlorite in a pre-perforated plastic bag that was renewed after disappearance of free residual chlorine. The maximum concentration of residual chlorine was reached after one day in 31 wells and in 5 wells after two days. On day 4 the chlorine level was less than 0.2 mg/l in half of the wells. The chlorine concentration was higher in family than community wells. Notwithstanding feasibility and acceptability issues, the device allowed chlorination at effective nontoxic levels for 3 days. These findings open the possibility of developing devices allowing longer diffusion at lower cost for use within the framework of integrated cholera epidemic control programs.

According to (Doocy and Burnham 2006), a study was carried out in Liberia in 2004 to test the effectiveness and appropriateness of some hand dug well treatment techniques. The conclusions were:

- Oxfam floating pot chlorinators can be adapted to well chlorination, adjusting the free residual chlorine (FRC) levels with the valve and the number of layers of rice bag. However, this method is not recommended because they are imported, expensive, and neither very effective nor very appropriate.
- Local simple pot chlorinators in plastic containers filled with layers of gravels, sand, and high tense hypochlorite HTH cannot be used, as the chlorine almost always dissolves too quickly, which is ineffective and inappropriate.
- Daily well chlorination with liquid bleach, to bring the FRC level up to 1.0 mg/L is quite effective and appropriate. It is however not recommended because it needs intensive monitoring and is quite complicated to implement quickly at a large scale.
- The best system is the pot chlorinator with a 70 g locally pressed (HTH) tablet and 2 liters of sand in a solid plastic bag, pierced twice with a needle and hung in the well at approximately half or two thirds of its depth. This proved both very appropriate, but was tested in a limited number of wells, all with relatively low chlorine demands (0.2 to 1.0 mg/L) with an average volumes, of 1.8 to 3.7 $m^3$and with 40 to 70 users per day. It should however be adaptable to wells with bigger volume, chlorine demand and/or abstraction by increasing the size and number of chlorine tablets and holes. This system proved effective during the rainy s, when major water related disease outbreaks are more likely to happen. It might not be adaptable to the dry season, when wells volumes are reduced.

2. Sanitation

Cholera is easily spread in environment where there is a lack of faeces sanitation. Appropriate facilities for human waste disposal are a basic need for all communities and many types are available to avoid open defecation and the subsequent pollution of water. For (“WHO | Guide to the Development of on-Site Sanitation” 2015), the objective of sanitary excreta disposal is to isolate feces so that the infectious agents in them cannot reach a new host. The method chosen for any particular area or region will depend on many factors including the local geology and hydrogeology, the culture and preferences of the communities, the locally available raw materials and the cost..

a. Latrines

The following methods has been performed by the WHO (“WHO | Guide to the Development of on-Site Sanitation” 2015):

- ✓ Shallow pit

People working on farms may dig a small hole each time they defecate and then cover the faeces with soil. This is sometimes known as the "cat" method. Pits about 300 mm deep may be used for several weeks. Excavated soil is heaped beside the pit and some is put over the faeces after each use. Decomposition in shallow pits is rapid because of the large bacterial population in the topsoil, but flies breed in large numbers and hookworm larvae spread around the holes. Hookworm larvae can migrate upwards from excreta buried less than 1 m deep, to penetrate the soles of the feet of subsequent users.

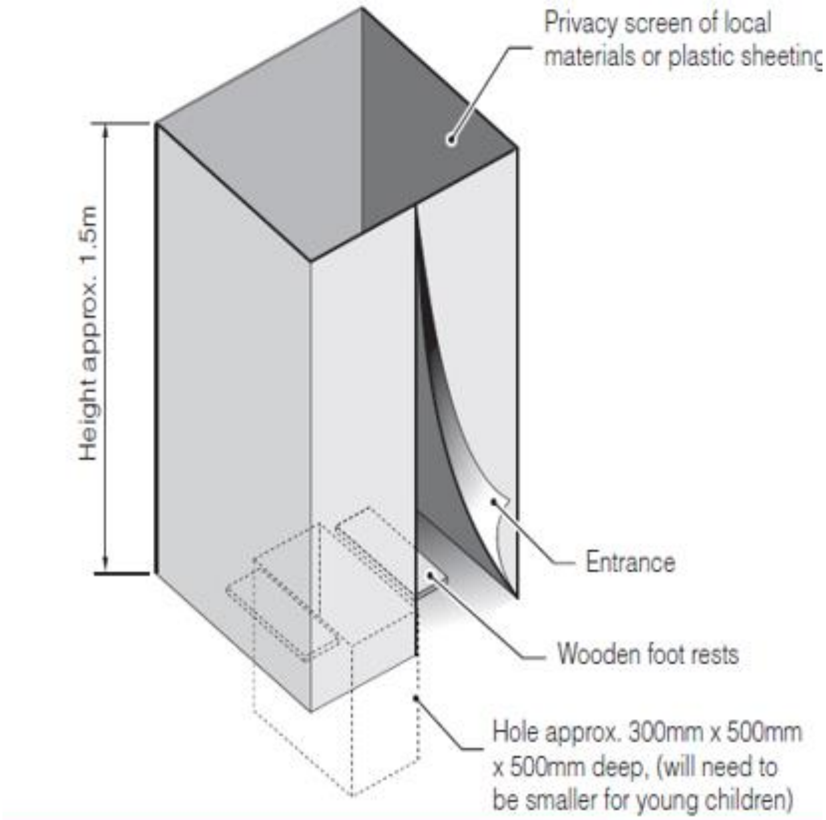

Figure 4: Family shallow pit latrine (Sow 2015)

- ✓ Simple pit latrine

This consists of a slab over a pit which may be 2 m or more in depth. The slab should be firmly supported on all sides and raised above the surrounding ground so that surface water cannot enter the pit. If the sides of the pit are liable to collapse they should be lined. A squat hole in the slab or a seat is provided so that the excrete fall directly into the pit.

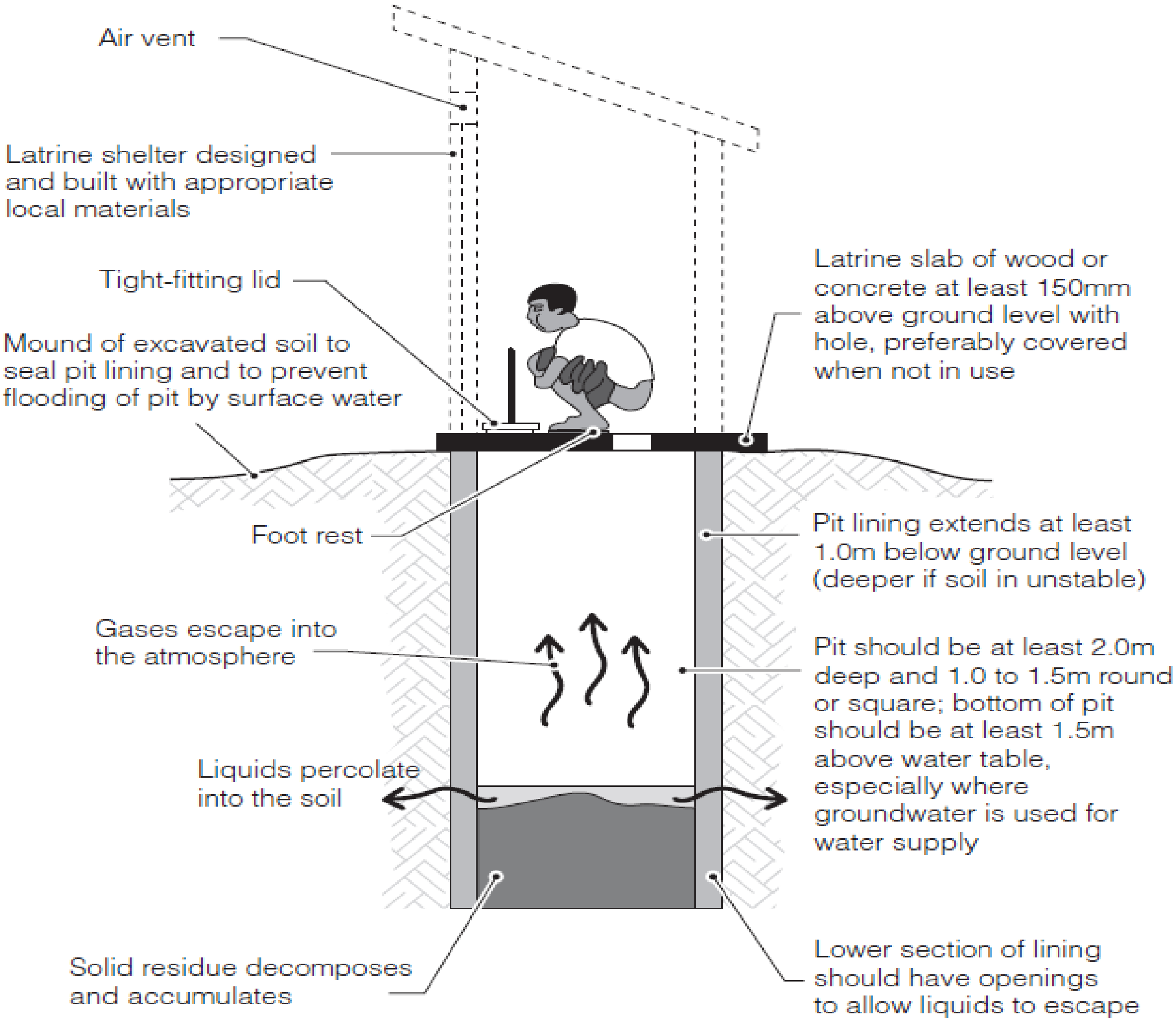

Figure 5: Simple pit latrine with superstructure (Sow 2015)

- ✓ Borehole latrine

A borehole excavated by hand with an auger or by machine can be used as a latrine. The diameter is often about 400 mm and the depth 6 to 8 m.

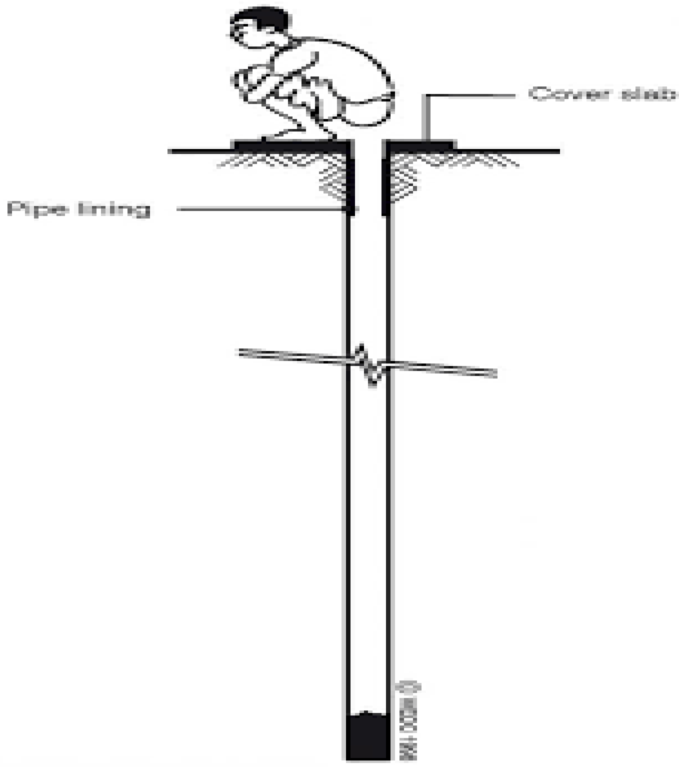

Figure 6: Borehole latrine ("Welcome to My WEDC" 2015)

- ✓ Ventilated pit latrines

Fly and odor nuisance may be substantially reduced if the pit is ventilated by a pipe extending above the latrine roof, with fly-proof netting across the top. The inside of the superstructure is kept dark. Such latrines are known as ventilated improved pit (VIP) latrines

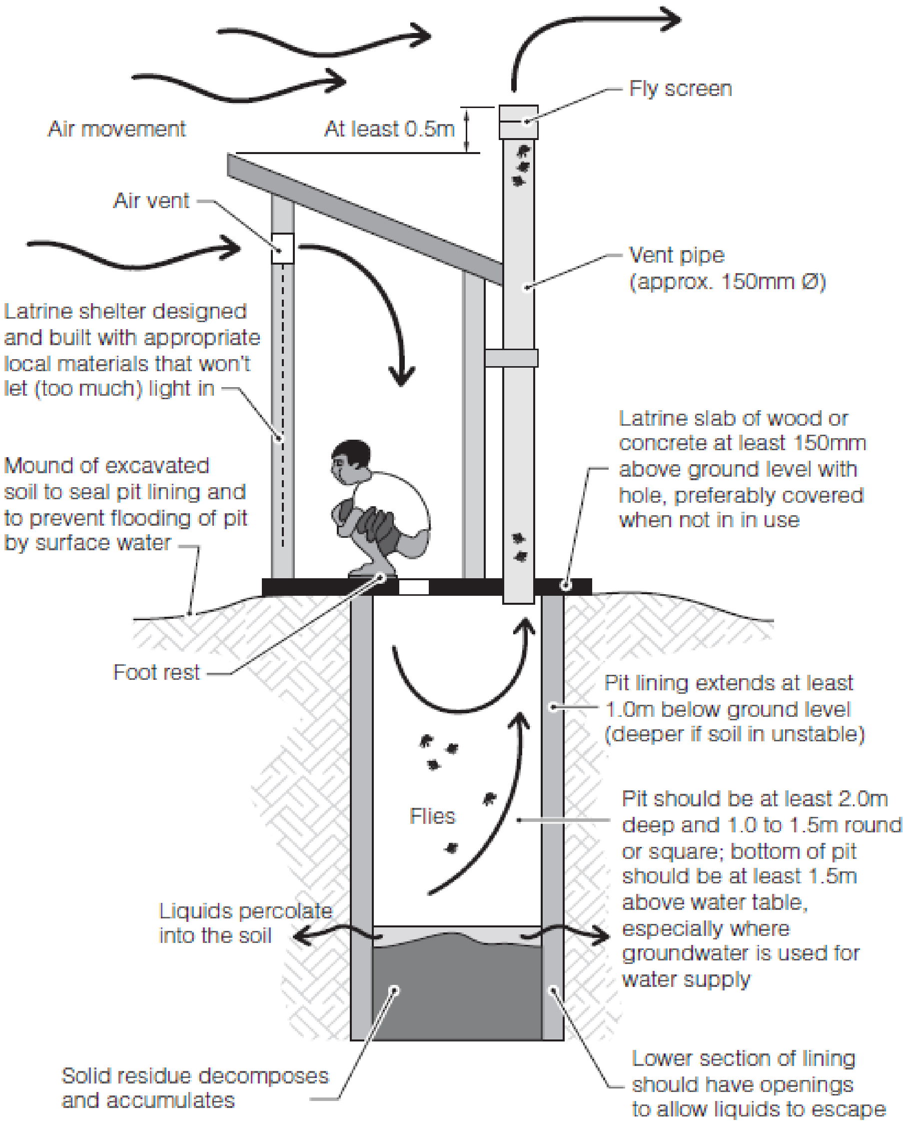

Figure 7: VIP latrine

Source: (Sow 2015)

- ✓ Pour-flush latrines

A latrine may be fitted with a trap providing a water seal, which is cleared of faeces by pouring in sufficient quantities of water to wash the solids into the pit and replenish the water seal. A water seal prevents flies, mosquitos and odors reaching the latrine from the pit. The pit may be offset from the latrine by providing a short length of pipe or covered channel from the pan to the pit. The pan of an offset pour flush latrine is supported by the ground and the latrine may be within or attached to a house.

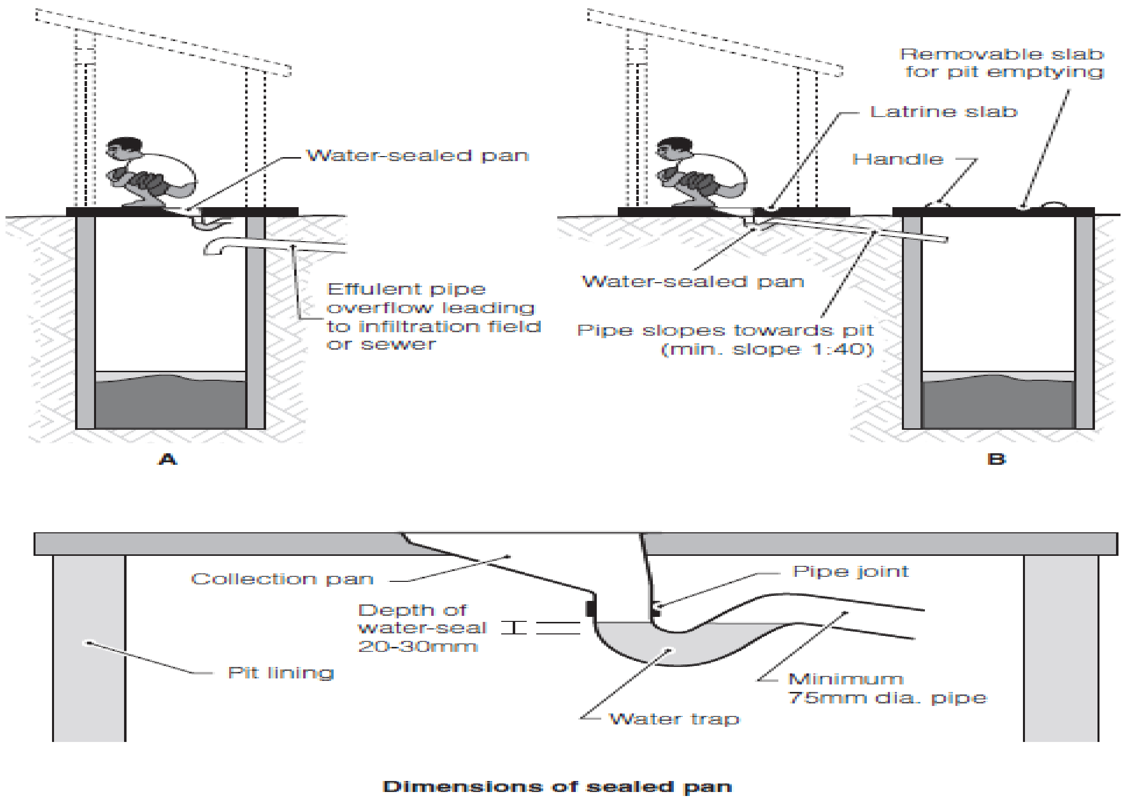

Figure 8: Pour-flush latrine (Sow 2015)

- ✓ Single or Double pit

In rural and low-density urban areas, the usual practice is to dig a second pit when the one in use is full to within half a meter of the slab. If the superstructure and slab are light and prefabricated they can be moved to a new pit. Otherwise a new superstructure and slab have to be constructed. The first pit is then filled up with soil. After two years, faeces in the first pit will have completely recomposed and even the most persistent pathogens will have been destroyed. When another pit is required the contents of the first pit can be dug out (which is easier than digging undisturbed soil) and the pit can be used again. The contents of the pit may be used as a soil fertilizer. Alternatively, two lined pits may be constructed, each large enough to take an accumulation of faecal solids over a period of two years or more. One pit is used until it is full, and then the second pit is used until that too is full, by which time the contents of the first pit can be removed and used as a fertilizer with no danger to health. The first pit can then be used again.

- ✓ Composting latrine

In this latrine, excrete fall into a watertight tank to which ash or vegetable matter is added. If the moisture content and chemical balance are controlled, the mixture will decompose to form a good soil conditioner in about four months. Pathogens are killed in the dry alkaline compost, which can be removed for application to the land as a fertilizer. There are two types of composting latrine: in one, compost is produced continuously, and in the other, two containers are used to produce it in batches

- ✓ Septic tank

A septic tank is an underground watertight settling chamber into which raw sewage is delivered through a pipe from plumbing fixtures inside a house or other building. The sewage is partially treated in the tank by separation of solids to form sludge and scum. Effluent from the tank infiltrates into the ground through drains or a soak pit. The system works well where the soil is permeable and not liable to flooding or waterlogging. The sludge is removed at appropriate intervals to ensure that it does not occupy too great a proportion of the tank capacity.

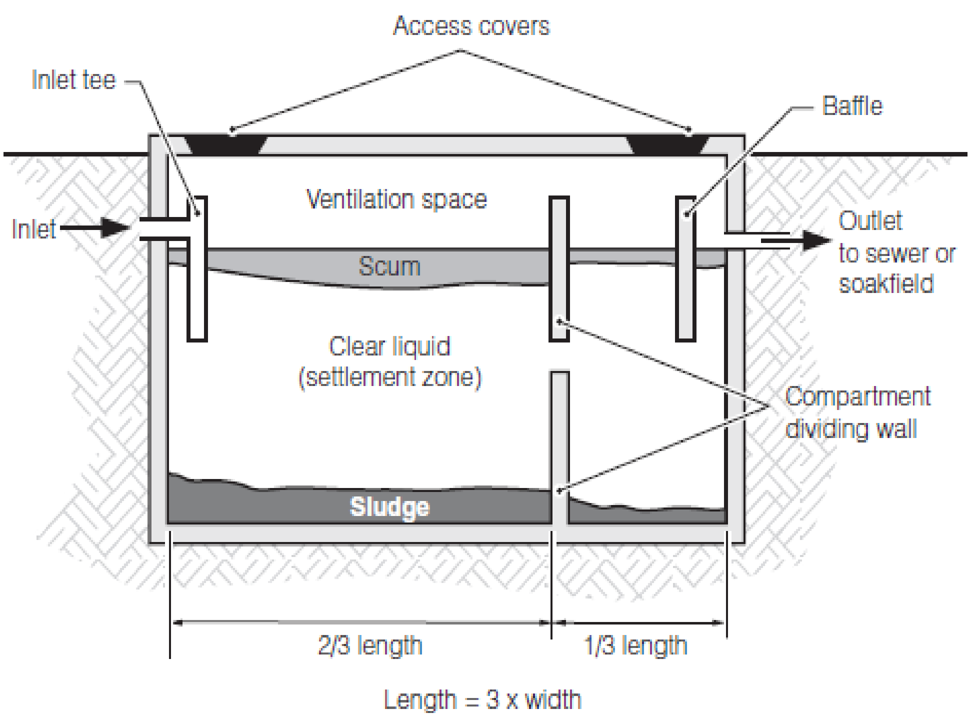

Figure 9: Septic tank (Sow 2015)

- ✓ Aqua-privy

An aqua-privy has a watertight tank immediately under the latrine floor. Excreta drop directly into the tank through a pipe. The bottom of the pipe is submerged in the liquid in the tank, forming a water seal to prevent escape of flies, mosquitos and smell from escaping. The tank functions like a septic tank. Effluent usually infiltrates into the ground through a soak pit. Accumulated solids (sludge) must be removed regularly. Enough water must be added to compensate for evaporation and leakage losses

- ✓ Bucket latrine

This latrine has a bucket or other container for the retention of faeces (and sometimes urine and anal cleaning material), which is periodically removed for treatment or disposal. Excreta removed in this way are sometimes termed night soil ("A Guide to the Development of on-Site Sanitation: Part I. Foundations of Sanitary Practice: Chapter 4. Technical Options: Aqua-Privy" 2015).

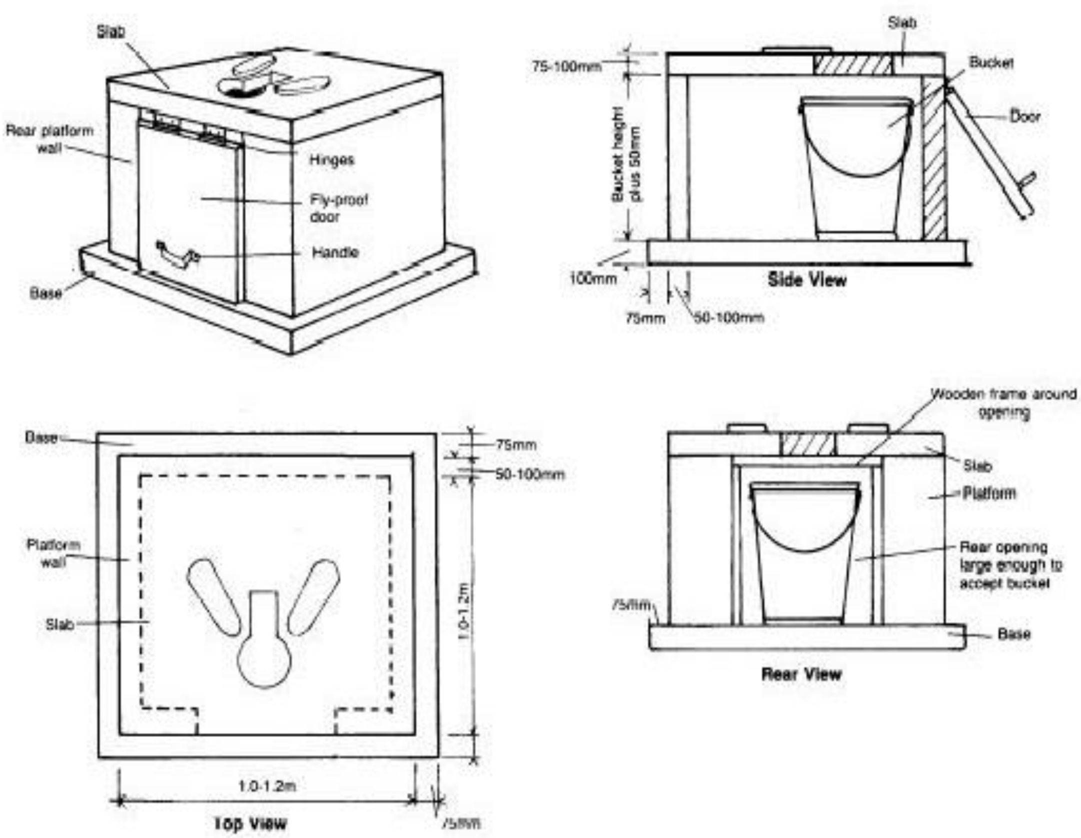

Figure 10: Bucket latrine (Sow 2015)

- ✓ Vaults and cesspits

In some areas, watertight tanks called vaults are built under or close to latrines to store excrete untie they are removed by hand (using buckets or similar receptacles) or by vacuum tanker. Similarly, household sewage may be stored in larger tanks called cesspits, which are usually emptied by vacuum tankers. Vaults or cesspits may be emptied when they are nearly full or on a regular basis. (“A Guide to the Development of on-Site Sanitation: Part I. Foundations of Sanitary Practice: Chapter 4. Technical Options: Aqua-Privy” 2015)

b. Peepoo bags

The Peepoo bag has been defined by (“WHO | WER Archives” 2015), as personal, single-use, biodegradable self-sanitizing double-plastic bag toilet. Peepoos contain sufficient powdered urea to inactivate harmful pathogens in urine and faeces after 4 weeks, at which time the waste can be used as fertilizer. Peepoos have been used where latrines are not feasible due to population density, and to bridge the gap between emergency onset and latrine construction.

We can learn from (Kesola, Kesola, and Wahlberg 2015) that after the earthquake, in Haiti OXFAM conducted a research trial on the introduction of a peepoo bag that was used in the camps or in the household as a defecation mechanism. The peepoo bags were then collected and transported outside the city, where the excreta were composted for agricultural purposes. The conducted trial received favorable responses because the bags are easy to use and since in Haiti defecating in a bag is not strange to people in Haiti. Furthermore the peepoo bags cuts the traditional link between water and sanitation problems, especially in places where water is scares. The peepoo bags can only be used as a temporary solution in an Emergency situation, until proper latrines are installed.

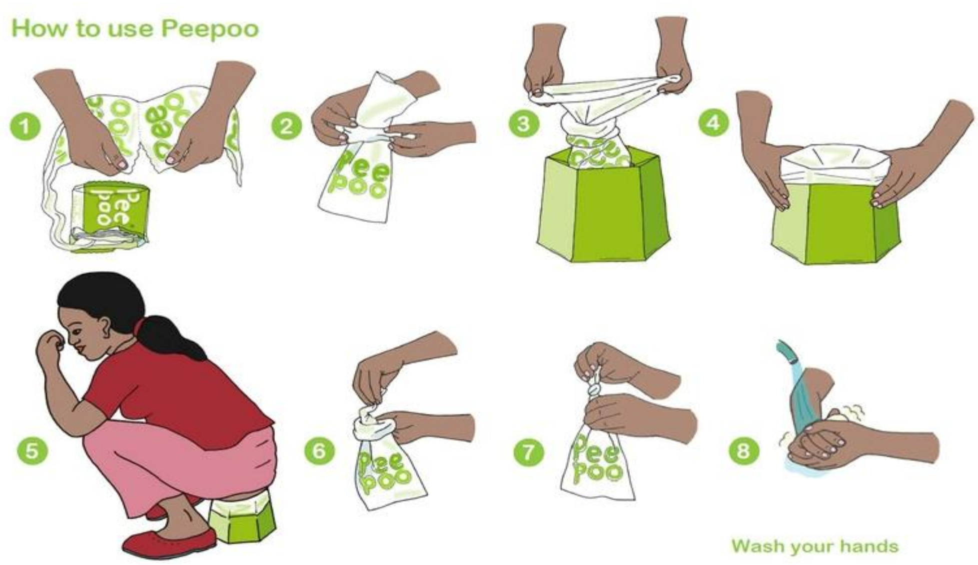

Figure 11: How to use peepoo bag (Greey 2015)

3. Hygiene promotion

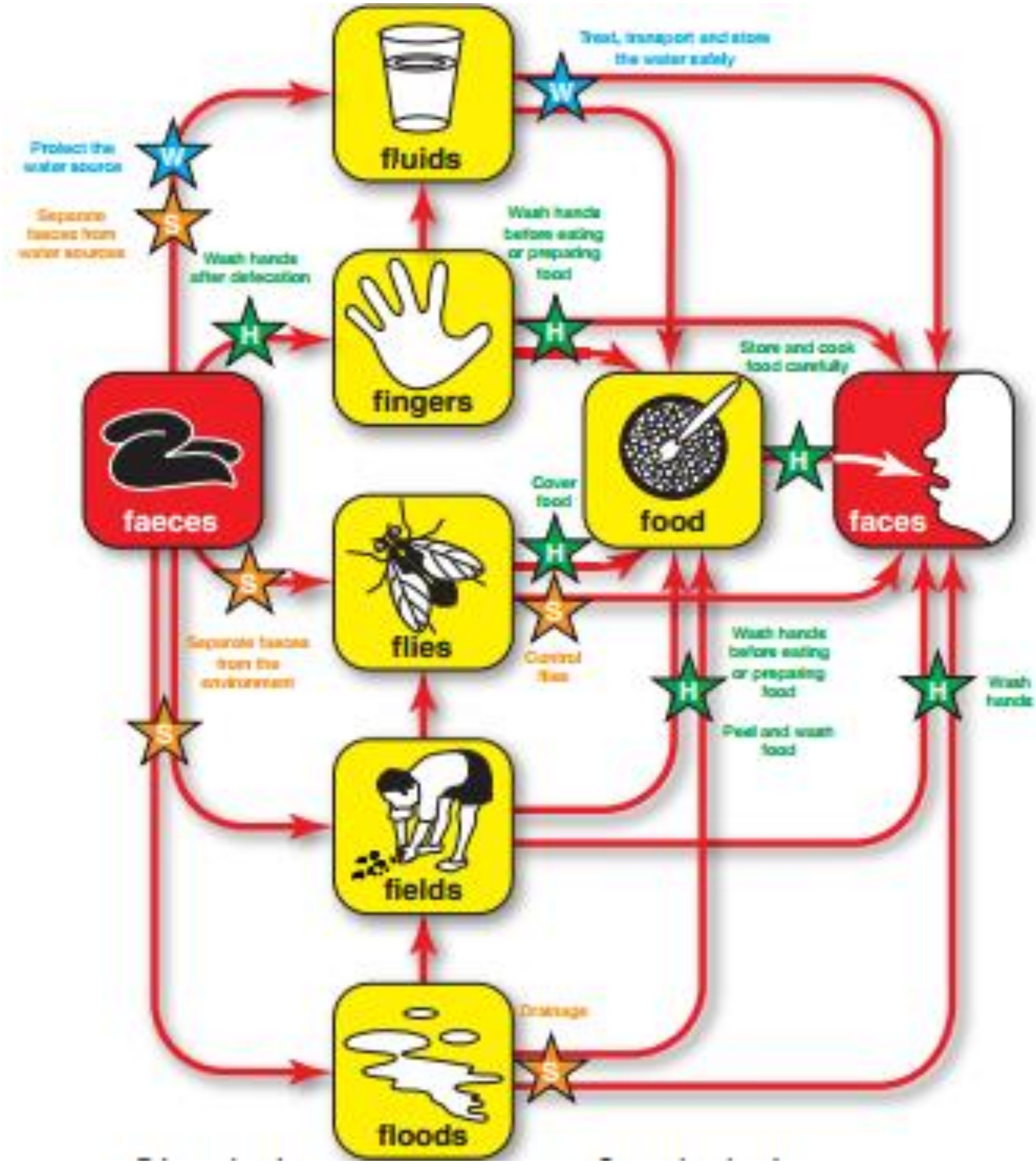

Figure 12: F-Diagram (WASHplus 2015)

The movement of pathogens from the faeces of a sick person to where they are ingested by somebody else can take many pathways, some direct and some indirect (figure 16).The main pathways t are easily memorized because they all begin with the letter ‘f’: fluids (drinking water) food, flies, fields (crops and soil), floors, fingers and floods (and surface water generally). Different types of barriers can stop the transmission of the disease. These can be primary (preventing the initial contact with the faeces) or secondary (preventing it being ingested by a new person). They can be controlled by water, sanitation and hygiene interventions.

For (Fewtrell et al. 2005), hygiene promotion is a very powerful tool to stop the spread of diarrheal diseases. The introduction of simple hand washing to the behavior of a population causes a 44% reduction of diarrheal diseases.

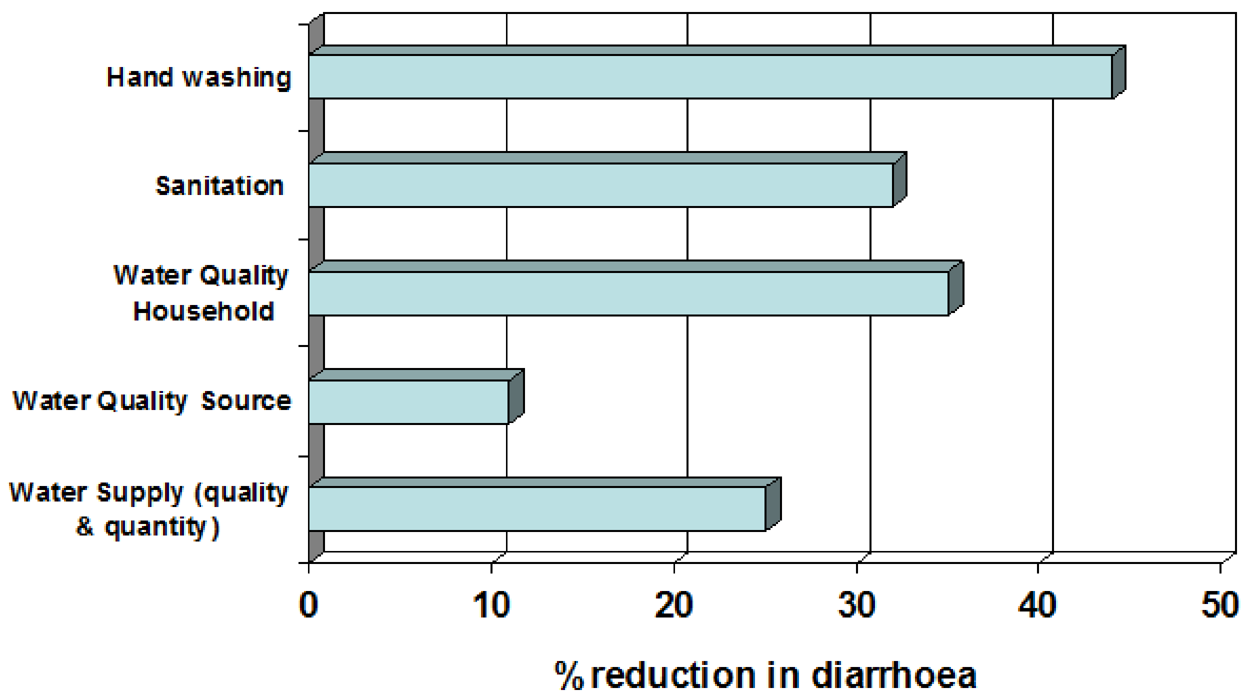

Figure 13: WASH interventions to reduce diarrhea in less developed countries: a systematic review and meta-analysis (Fewtrell et al. 2005)

From (Beau De Rochars et al. 2011) article, the Somalia WASH cluster response plan, preconized key messages for health education:

- Cholera is a disease that causes watery diarrhoea. It causes rapid loss of water and salts from the body (dehydration) which can lead to death within hours if not treated.

- If you or a family member have watery diarrhoea and vomiting, go to the health care facility immediately.

- Start drinking ORS or treated water at home and during travel to the health care facility.

- Cholera spreads quickly. Protect yourself from cholera germs; Wash your hands with running water and soap or ash before eating, after wiping a child's bottom and after using the toilet/ defecating.

- Continue breast feeding a sick child and encourage the child to eat regularly.

- Food: COOK IT – PEEL IT – OR LEAVE IT

- Drink safe water. Safe water is chlorinated, bottled, boiled or filtered water.

- Use latrines: If you have no latrine, bury faeces 30 meters from any body of water

- Thoroughly wash your hands with soap and water after taking care of people with cholera, touching them, their stools, vomit, or clothes.

V. DISCUSSION

Cholera can be stopped by implementing water treatment facilities and by changing people's behaviors. All these methods have advantages and disadvantages. The challenge is to find the best action to implement in a given context.

A. Water treatment

Among the water treatment methods discussed previously, there were good and less good methods depending on the context..

The well chlorination using pot chlorinator has variable results.

In general, it is recommended that pot chlorinators should not be used for high-risk, lined wells during a cholera outbreak. Instead, these wells can be chlorinated directly using HTH chlorine on a regular basis. Residual chlorine testing should be done several times a day.

It is not recommended to chlorinate unlined wells because the chlorine will be used up by the organic materials of the well walls, so it will be difficult to establish or maintain the target levels of free chlorine residual. Instead, when a well is unlined, household water treatment should be promoted.

Solar disinfection is most appropriate in areas where bottles are available and there is repeated community training on how to correctly and consistently use solar disinfection for treating household drinking water. Effectiveness is reduced for very turbid water.

Sand filtration is most appropriate in areas where there is external funding to subsidize the initial cost of the filter, education for users, locally available sand, and a transportation network capable of moving the buckets and sand. It might not be feasible in emergency contexts.

Household Chlorination is most appropriate in areas with a consistent water supply chain, with relatively lower turbidity water, and situations where educational messages can reach a target population to encourage correct and consistent use. It is the best way to kill bacteria in the water and to keep the water free from any further bacteria contamination.

B. Sanitation

The first step to fight against cholera is to free the environment in general and specifically, food production areas, public centers and surroundings of drinking water sources, from human fecal contamination. That can be done using:

Peepoo bags are easy to use and can be rapidly provided at the first step of an emergency situation. This is a relatively good solution to avoid the fecal pollution of the environment, notwithstanding it requires a workforce to collect the bags and a safe disposal site to dispose the bags.

The shallow pit latrine, the simple pit latrine and the borehole latrine: They are easily implementable even by the population, they do not need water for operation and they are suitable for short-term use. However they are not suitable in flooded or swampy areas because of the high risk of pollution of the groundwater. Fly nuisance is also a problem.

The VIP latrine, the septic tank, the pour-flush latrine, the aqua privy: They allow the control of flies, and are suitable for middle or long-term use. Because of their high cost they cannot be implemented when funds are limited and their use sometimes requires water.

The bucket latrine: Their initial cost is low and they are suitable for places where it is not possible to dig. However they can harm the health of those who collect them and they also need to be disposed in a safe disposal site.

Table 4: Advantages vs Disadvantages of sanitation facilities

Source: *("WHO | Guide to the Development of on-Site Sanitation" 2015)*

	ADVANTAGES	DISADVANTAGES
Shallow pit	No cost	Considerable fly nuisance
	Benefit to farmers as fertilizer	Spread of hookworm larvae
Simple pit	Low cost	Considerable fly nuisance (and mosquito nuisance if the pit is wet) unless
	Can be built by houseowner	there is a tight-fitting cover over the squat hole when the latrine is not in use
	Needs no water for operation	
	Easily understood	
borehole latrine	Can be excavated quickly if boring equipment	Sides liable to be fouled, with consequent fly
	is available	nuisance
	Suitable for short-term use, as in disaster	short life owing to small cross sectional area
		Greater risk of groundwater pollution owing to depth of hole
VIP latrines	Low cost	Does not control mosquitos
	Can be built by householder	Extra cost of providing vent pipe
	No water needed for operation	Need to keep interior dark
	Easily understood	
	Controls flies	
	Absence of smell in latrines	
pour-flash latrines	Controls flies and mosquitos	Unsuitable where solid anal cleaning material is used
	Absence of smell	Contents of pit not visible
	Gives users the convenience of a WC	A reliable (even if limited)water supply must be available
	Can be upgraded by connection to sewer when sewge becomes available	
	Pan supported by ground	
	Latrine can be within a house	
double pit latrine	Once constructed the pits are relatively permanent	Cost
	Pit contents can be safely used as a soil conditioner alter 2 years, without treatment	
	Easy removal of solids from the pits as they are shallow	
Composting latrine	A valuable humus is produced	Careful operation is essential
		Urine has to be collected separately in the batch system
		Ash or vegetable matter must be added regularly
Septic tank	Gives the users the convenience of a WC	High cost
		Reliable and ample piped water required
		Only suitable for low-density housing
		Regular dislodging required and sludge needs careful handling
		Permeable soil required
Aqua-privy	Does not need piped water on site	Water must be available nearby
	Less expensive than a septic tank	More expensive than VIP or pour-flush latrine
		Fly mosquito and smell nuisance if seal is lost because insufficient water is added
		Regular desludging required and sludge needs careful handling
		Permeable soil required to dispose of effluent
Bucket latrine	Low initial cost	Malodorous
		Creates fly nuisance
		Danger to health of those who collect or use the nightsoil
		Collection is environmentally and physically undesirable
Vaults and cesspits	Satisfactory for users where there is a reliable	High construction and collection costs
	and safe collection service	Removal by hand has even greater health risks than bucket latrines
		Irregular collection can lead to tanks overflowing
		Efficient infrastructure required

C. Hygiene promotion

Hygiene promotion can lead to a 44% reduction of diarrhea diseases. For hygiene promotion to be be effective, hygiene promoters should consult and mobilize communities to:

- Ensure that new WASH facilities are acceptable and used.
- Establish systems for cleaning and maintenance of public facilities.
- Motivate people to take action to improve hygiene and seek treatment.
- Give training on how to use unfamiliar facilities such as household water treatment products.

VI. CONCLUSION

Overall, cholera fatality rate has drastically been reduced due the knowledge of cholera symptoms, prevention, treatment, and modes of transmission. All of the studies proved that water treatment, safe extra disposal facilities and public health messages have been effective on preventing or stopping cholera outbreaks. Most of our reviewed articles made the recommendation to run further researches, further field trial in order to be capable to implement the correct cholera response depending on the local parameters.

Non WASH activities such as vaccination and cholera surveillance are also important to prevent outbreaks. Further studies should be done to improve cholera detection systems. According to ("WHO | WER Archives" 2015), there is an urgent need for to undertake a comprehensive assessment of individual rapid detection tests (RDTs) developed for cholera through a standardized procedure to promote and facilitate access to safe, appropriate and affordable RDTs of good quality in an equitable manner. WHO Global Task Force for Cholera Control (GTFCC) is now streamlining implementation and effective use of RDTs. Further studies should be done to understand the natural living cycle of vibrion cholerae in order to fight against it directly in his source. A strong initiative by international organizations and by national governments should be made to strengthen cholera surveillance and make this the conduit for connecting physicians, health workers and institutions in a collaborative way to understand global cholera burden.

VII. REFERENCES

1 "A Guide to the Development of on-Site Sanitation: Part I. Foundations of Sanitary Practice: Chapter 4. Technical Options: Aqua-Privy." 2015. Accessed October 31. http://helid.digicollection.org/es/d/Jh0210e/2.4.10.html.

2 Beau De Rochars, Valery E. M., Julie Tipret, Molly Patrick, Lara Jacobson, Kamil E. Barbour, David Berendes, Diana Bensyl, et al. 2011. "Knowledge, Attitudes, and Practices Related to Treatment and Prevention of Cholera, Haiti, 2010." *Emerging Infectious Diseases* 17 (11): 2158–61.

3 Cholera Working Group, International Centre for Diarrhoeal Diseases Research, Bangladesh, M. J. Albert, M. Ansaruzzaman, P. K. Bardhan, A. S. G. Faruque, S. M. Faruque, M. S. Islam, et al. 1993. "Large Epidemic of Cholera-like Disease in Bangladesh Caused by Vibrio Cholerae 0139 Synonym Bengal." *The Lancet*, Originally published as Volume 2, Issue 8868, 342 (8868): 387–90. doi:10.1016/0140-6736(93)92811-7.

4 Colwell, Rita R. 1996. "Global Climate and Infectious Disease: The Cholera Paradigm*." *Science* 274 (5295): 2025–31. doi:10.1126/science.274.5295.2025.

5 Colwell, Rita R., Anwar Huq, M. Sirajul Islam, K. M. A. Aziz, M. Yunus, N. Huda Khan, A. Mahmud, et al. 2003. "Reduction of Cholera in Bangladeshi Villages by Simple Filtration." *Proceedings of the National Academy of Sciences of the United States of America* 100 (3): 1051–55. doi:10.1073/pnas.0237386100.

6 Conroy, R, M Meegan, T Joyce, K McGuigan, and J Barnes. 2001. "Solar Disinfection of Drinking Water Protects against Cholera in Children under 6 Years of Age." *Archives of Disease in Childhood* 85 (4): 293–95. doi:10.1136/adc.85.4.293.

7 Doocy, Shannon, and Gilbert Burnham. 2006. "Point-of-Use Water Treatment and Diarrhoea Reduction in the Emergency Context: An Effectiveness Trial in Liberia." *Tropical Medicine & International Health* 11 (10): 1542–52. doi:10.1111/j.1365-3156.2006.01704.x.

8 Fewtrell, Lorna, Rachel B Kaufmann, David Kay, Wayne Enanoria, Laurence Haller, and John M Colford Jr. 2005. "Water, Sanitation, and Hygiene Interventions to Reduce Diarrhoea in Less Developed Countries: A Systematic Review and Meta-Analysis." *The Lancet Infectious Diseases* 5 (1): 42–52. doi:10.1016/S1473-3099(04)01253-8.

9 Glass, Roger I., and Robert E. Black. 1992. "The Epidemiology of Cholera." In *Cholera*, edited by Dhiman Barua and William B. Greenough III, 129–54. Current Topics in Infectious Disease. Springer US. http://link.springer.com/chapter/10.1007/978-1-4757-9688-9_7.

10 Greey, Meredith. 2015. "Meet the Peepoople." *Innovate Development*. Accessed October 29. http://innovatedevelopment.org/2014/11/19/meet-the-peepoople.

11 Guévart, E., C. Van Hecke, J. Noeske, J. Sollé, A. Bita Fouda, and B. Manga. 2008. "[Handmade devices for continuous delivery of hypochlorite for well disinfection during the cholera outbreak in Douala, Cameroon (2004)]." *Médecine Tropicale: Revue Du Corps De Santé Colonial* 68 (5): 507–13.

12 Kesola, Serette, Serette Kesola, and Johanna Wahlberg. 2015. "Successful Community Rally against Cholera Based on Literature Review." http://www.theseus.fi/handle/10024/96825.

13 "Progress on Drinking Water and Sanitation 2014 Update | UNICEF Publications | UNICEF." 2015. Accessed October 27. http://www.unicef.org/publications/index_73448.html.

13 Sow, souleymane. 2015. "Household Treatment Storage." In , 26.

14 “Svadlenka Improving Local Water.” 2015. Accessed October 29. http://www.whyhunger.org/getinfo/showPhotoAlbum/photoAlbumId/2659.
15 Taylor, Dawn L., Tanya M. Kahawita, Sandy Cairncross, and Jeroen H. J. Ensink. 2015. “The Impact of Water, Sanitation and Hygiene Interventions to Control Cholera: A Systematic Review.” Edited by Zulfiqar A. Bhutta. *PLOS ONE* 10 (8): e0135676. doi:10.1371/journal.pone.0135676.
16 WASHplus. 2015. “WEDC - WASH Posters Prepared for the WEDC Conference.” *Sanitation Updates*. Accessed October 29. https://sanitationupdates.wordpress.com/2013/07/02/wedc-wash-posters-prepared-for-the-wedc-conference/.
17 “Welcome to My WEDC.” 2015. Accessed October 29. https://wedc-knowledge.lboro.ac.uk/details.html?id=21335.
18 “WHO | Cholera.” 2015. *WHO*. Accessed October 22. http://www.who.int/topics/cholera/en/.
19 “WHO | Guidelines for Drinking-Water Quality, 2nd Edition.” 2015. *WHO*. Accessed October 29. http://www.who.int/water_sanitation_health/dwq/gdwq2v1/en/index2.html.
20 “WHO | Guide to the Development of on-Site Sanitation.” 2015. Accessed October 29. http://www.who.int/water_sanitation_health/hygiene/envsan/onsitesan/en/.
21 “WHO | Prevention and Control of Cholera Outbreaks: WHO Policy and Recommendations.” 2015. Accessed October 31. http://www.who.int/cholera/prevention_control/recommendations/en/index5.html.
22 “WHO | WER Archives.” 2015. *WHO*. Accessed October 22. http://www.who.int/wer/archives/en/.