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Household water filters and waterborne epidemics: a case study from South Sudan

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PAPER [OFFICE USE ONLY]

In 2016, the Technical Working Group (TWiG) of the national WaSH Cluster of South Sudan focused on water filter technologies in order to assess the suitability of the many filter products available for application in WaSH interventions within South Sudan. However, the TWiG didn't analyse past disasters and water borne epidemics together with endemic diseases, even if it can be useful to identify the risk and type of new potential epidemics and finally choose the best filter (or other water treatment) to be distributed.

Background

In 2016, the Technical Working Group (TWiG) of the national WaSH Cluster of South Sudan focused on water filter technologies in order to assess the suitability of the many filter products available for application in WaSH interventions within South Sudan.

The objective of the TWiG was to compile technical guidelines for appropriate water filter technologies/products for application in WASH programs in South Sudan presenting the technical specifications and lessons learned related to four different filters distributed by four members of TWiG included PAH, Oxfam, Medair and Solidarites International, with Medair serving as the TWiG focal point.

A single filter product was not recommended, as there are many different contexts and factors that contribute to the success of a filter-based intervention.

The TWiG's feedback was written in a document that includes:

1. Comparison and summary of the key technical specifications and advantages/disadvantages encountered in the field;
2. Finding reports from each TWiG member agency: ceramic filters (PAH), Griffaid (Solidarities International), Life Saver Cube (Oxfam), and Sawyer PointOne (Medair) (TWiG, 2016).

Starting from South Sudan TWiG's document and considering data of epidemic outbreaks during and after crisis, this paper, and the following related poster, wants to debate and make debate about opportunities, limitations and requirements of different water filters in different contexts and for different epidemics.

After a disaster, skin, diarrheal and respiratory diseases are often the most common diseases in survivors. However, usually a disease must be endemic of the area to become an epidemic after a disaster. Nevertheless, the lack of report of a specific disease does not mean that that disease is not present in the population and infections can come even from external population; as with the well-known case of the cholera epidemic in Haiti in 2010. Therefore, it is not possible to predict with accuracy which diseases will occur following certain types of disasters (KOUADIO, 2012).

Moreover, an epidemic caused by a disaster depends also on environmental conditions, pre-event structures, public health system in place, immunization rate of population and, of course, magnitude of disaster.

To be considered also is that the highest risks for water borne diseases come from disasters such as hurricanes, floods, famines and civil war/refugees displacements (LEMONICK, 2011).

Furthermore, Viral hepatitis A and E are common in countries or areas where existing sewage disposal and sanitation system are inadequate (KOUADIO, 2012). Hepatitis A is endemic in most developing countries, and most children are exposed and develop immunity at an early age (WATSON, 2007). On the other hand, Hepatitis E has only recently been introduced in most parts of Africa, so adults are unlikely to have immunity to it (LEMONICK, 2011). HEV outbreaks results in high mortality rate among pregnant women.

In Asia, HEV outbreaks have been reported only in 12 countries (mostly India but also Indonesia, Myanmar, Vietnam, Japan, China, Bangladesh, Pakistan, Nepal, Iraq, Uzbekistan and Turkmenistan), in Africa in 15 countries (Egypt, Kenya, Sudan, South Sudan, Central African Republic, Uganda, Chad, Republic of Djibouti, Algeria, Namibia, Morocco, Somalia, Ethiopia, South Africa and Cameroon), in the Americas and Europe in 4 countries (UK, Italy, Mexico and Cuba) (HAKIM, 2016).

Leptospirosis is usually reported following flooding in developing countries (KOUADIO, 2012).

However, the main causes of epidemics after a disaster are displacement and crowding of population (LEMONICK, 2011) and there is no scientific evidence that there is a high risk of infectious disease transmission and outbreaks shortly after a natural disaster especially when the disaster has not resulted in substantial population displacement (KOUADIO, 2012).

Because water-borne diseases can be anticipated for up to one month (LEMONICK, 2011) and specific material can be stocked for specific contexts, keeping in mind the considerations above, a better choice of WaSH intervention, and specifically of water filter, can be prepared and implemented for different disasters.

Rationale (technical justification)

In 2016 the distribution of household water filters in South Sudan was justified mainly by the following considerations:

- The country was affected by recurrent crisis that makes people displace repeatedly;
- Local markets didn't provide, especially during crisis, affordable household water treatments options.

Because of this, distribution of a household, compact and easy to carry, filter was considered a good solution to provide a more sustainable water treatment technology to people in recurrent movement.

Furthermore, other characteristics were analyzed in relation to South Sudanese context as for example:

treatment capacity, storage capacity, ease to use/acceptance, follow-up training required, accompanying NFI required, contamination risks, flow rate, maintenance requirements, life span, dimension, cost.

However, in the TWiG document there is no analysis of past disasters and water borne epidemics together with endemic diseases and the other parameters listed above. Nevertheless, it can be useful, as explained above, to identify the risk and type of new potential epidemics in order to choose the best filter (or other water treatment) to be distributed.

Methodology

In 2016, four NGOs belonging to the TWiG of WaSH Cluster distributed in different areas of South Sudan four different types of household water filters.

Each NGO independently decided how to do the Post Distribution Monitoring (PDM) and how to collect data from the field and/or laboratory and/or manufacturer. Each NGO provided a different report with the collected information and a common table was filled to summarise and better compare the filters.

PAH distributed the ceramic water filters to ten households in the five villages of Juba Na Bari together with a basic training on how to use the filters. The Hygiene promoter's team leaders monitored the use of the filters (TWiG, 2016).

In 14 Bomas of Nyilwak and Pakwar Payams of Panyikang County, Solidarites International distributed the filters and provided instruction leaflets and training. Some technical data for the TWiG report were provided by the filter manufacturer and most of the information was collected through a PDM using a questionnaire with simple structured questions. A sample size of 284 (32%) was selected out of the 881 households that had received the filters. Households were selected from each Boma (village) using the ''Throwing a pen'' method.

Samples were collected from 20 households and tested for thermo-tolerant coliform (TWiG, 2016).

From January 2015 to March 2016 Oxfam distributed 1215 Cube's to the Islands near Nyal, 180 to the swamp inhabitants near Pultuk and 955 in a ponds and rivers area near Bangolo. Oxfam collected data on the acceptance and use of the filter from a random sample of houses in each of the 3 locations following a simple check list of questions.

Medair distributed approximately 5,000 Sawyer PointONE filters from 2015-16 and a further 1,603 in 2017. These were given along with training and follow-up in various contexts throughout South Sudan: during a period of intense fighting to populations in remote areas travelling within the swamps; in response to an influx of IDPs with a follow up post-distribution monitoring survey conducted two months later; as part of cholera prevention to dispersed populations living within the swamp and Nile region, within an IDP/returnee settlement with monthly water quality sampling and an ongoing quarterly household survey evaluating use and acceptance. Details of longer-term Sawyer study are presented in Holding et al. (under review).

Later, in 2018, a desk review of literature tried to identify the link between viral and bacterial epidemics with disasters. The objective was to identify the best filter pore size considering that virus are smaller than bacteria.

The used methodology was limited by the different approaches of the four different NGOs. In fact, the four assessments differentiated meanly, but not only, for:

- number of distributed filters,
- populations (even if belonging to similar contexts),
- PDM (sample, frequency, questionnaire etc.),
- training and instruction leaflets,
- laboratory methodology (both of manufacturers and NGOs)

Moreover, due to security reasons, in some cases it was not possible to conduct a second PDM, crucial to understand the sustainability over the longer term of the filter and the capacity of beneficiaries to carry the filters with them in case of recurrent crisis.

Furthermore, the epidemiological data of the CRED database, analysed during the desk review are not limited only to waterborne epidemics and the recorded disasters do not include conflicts. In addition, the correlation between different types of epidemic and other disasters occurring in the same year have high variation from year to year and they may not have correlation at all, as they may affect different populations.

Data from other sources do not always distinguish between different origins of diarrheal diseases and the selection of studied outbreaks is sometimes done for other purposes and, because of this, it can create some bias.

Findings

The study of the TWiG summarised the feedback about the four filters in the following table:

Table 1. Main findings of TWiG study

Indicator	Chujio	GriffAid	LifeSaver Cube	Sawyer
Technological basis	Ceramic pot (enhanced with silver nitrate)	Membrane (pumping)	Nano-membrane (pumping)	Hollow fiber membrane (gravity)
Treatment capabilities (bacteriological /viral – supplier information and/or field tests)	Removal of water borne pathogens, > 99.99% E. coli reduction, >94% turbidity reduction, 60-70% reduction in diarrheal disease Up to 0.2µm pore	Log 10 bacteria and virus removal 0.01µm pore	Log 6 bacteria removal Log 4 virus removal (according to the latest tests January 2016) 0.015µm	0.1µm pore 99.9% bacteria, protozoan parasites
Capacity (vol)	10L filter and 10L storage	Variable, dependent on bucket size. Typically 20L but could be larger	5L storage	Variable, dependent on bucket size. Typically 20L but could be larger

Contamination potential concerns	Limited contamination as safe water stored separately so only drinking vessel	Reduced risk of recontamination because water is stored untreated and treated only as it is used.	Reduced risk of recontamination because water is stored untreated and treated only as it is used.	Potential contamination from handling of filter outlet during back-washing
Flow rate (reported and field-tested)	2L/hour	90L/hour according to manufacture	60L/hour; slower when high turbidity in raw water	Reported 46L/hour; Field tested 12-24L/hour
Life span	Manufacturer claims 2 years, but dependent on individual filter handling	Manufacturer claims 5 years (100,000 L), but dependent on maintenance and raw water quality	Manufacturer claims 5,000L; untested.	Manufacturer claims up to 6 years, but dependent on maintenance and raw water quality
Portability (for user and for distribution logistics)	0.4x0.3m; 3kg Fragile	0.5x0.14x0.1m; 1.2kg	0.2x0.2x0.2m; 1.2kg	0.15x0.04m; 0.23kg
Cost	30 USD	53 USD	30 USD (20GBP)	13 USD
Lessons learned and specific concerns for South Sudanese context	+simple to use/maintain +no unacceptable taste/smell from chlorination +potential for local manufacturing -slow filtration rate -dissolving of filter pot material -potential for breakage with improper handling -lack of elevation for filter (table/stool) -size of filter not sufficient for HH	+preferred taste over raw water or chemical treatment +limited risk of improper use leading to unsafe water -frequent backwashing required when water turbid -decreasing flow rates without proper maintenance -positive safe water storage needed for filtered water management -the glue to fasten the pipes and the stopper is weak that can lead a lot of damaged units -the items requires for regular operation and maintenance (grease to make the pump continue to be easy to	+pack and pile easily for transport with no small component parts to go missing en route +preferred taste over raw water or chemical treatment +limited risk of improper use leading to unsafe water -was not carried during subsequent displacements -difficult to fill through small opening on inlet -requires both lids to be tightly fastened in order to operate -can be broken when handled roughly with observed weak spots: pump handle, tap nozzle, and cap	+allows for typical “batch” water filtration +lightweight and portable (was observed carried with displaced population) -frequent backwashing required when water turbid -decreasing flow rates without proper maintenance -positive safe water storage needed for filtered water management -lack of elevation limits flow rate

		operate and spare seals) seems to finish or lost soon after the distribution	threads can be broken, lost O-rings -filter membrane cannot dry out, must always be some water in filter	

As it is shown in the findings, some filters thanks to their pore size (GriffAid and Life Save Cube), even if they can be more expensive and/or more complicated to maintain and store, can remove virus, while the others not.

However, it is not clear if during disasters, populations are affected more by virus epidemics or bacterial epidemics. In fact, according to CRED database, from 1900 to 2017 people affected by viral epidemics have been more than 9 million so 0,12% of people affected by all natural disasters while those affected by bacterial epidemics were almost half of them (0,06% of people affected by all natural disasters).

Nevertheless, people who died because of viral epidemics are only 2% of the deaths due to all natural disasters, so much less than the ones who died because of bacterial epidemics which are 15% of the deaths due to all natural disasters (EM-DAT, 2017).

Moreover, out of the 21 articles describing outbreaks reasonably caused by natural disasters analyzed by Kouadio et Al., 16 are related to waterborne epidemics possibly due to ingestion of contaminated water. Out of these 16 outbreaks, only 1 was exclusively due to a viral infection (norovirus), 7 exclusively due to bacterial infections (E.Coli, V.Cholerae, Leptospira, Salmonella enterica), 2 due to both viral (norovirus) and bacterial (V.Cholerae) infections, 2 due to viral (HEV, HAV) infection and other unknown infections causing diarrhea and 4 due only to unknown infections causing diarrhoea (KOUADIO, 2012).

So if we do a sort of sensitivity analysis, after a natural disaster, if epidemics due to ingestion of contaminated water occur, between 25% and 50% are also or only of viral origin while 56% to 94% are also or only of bacterial origin (depending if unknown infections are considered viral or bacterial).

Furthermore, out of the 35 outbreaks analysed by Brucker and Checchi, only 6 were related to ingestion of contaminated water. Out of these 6, 4 are caused by bacterial infection (E.Coli, V.Cholerae, Shigella dysenteriae) and 2 by viral infection (HEV) (BRUCKNER, 2011).

Globally HEV has an Age-standardized death rate (AS-DR) and Age-standardized Disability-Adjusted Life Year (AS-DALY) similar to the ones of Paratyphoid fever and Ascariasis infections. Anyway, the two indicators are much lower than the ones of typhoid fever and general diarrheal. However, diarrheal diseases include several types of infection, both viral and bacterial. HAV has AS-DR and AS-DALY lower than HEV. Even if there are different trends between one country and another, no big differences are identified between low-income countries' and global values (GHDX).

In addition, according to WHO, globally between 2000 and 2013 only 37% of deaths due to diarrhoea are caused by an infection of rotavirus, one of the main diarrheal viral infections. Similar percentages can be found in most of the country without big difference due to geography, economy or fragility of the state (WHO).

Challenges and conclusion

Because of the limitations mentioned in the methodology and discrepancy between data on affected and dead people, further specific research is needed.

However, it looks clear that the analysis of historical epidemics of waterborne diseases in the area of intervention, together with considerations about the general context and technical characteristics of the available treatment devices, can help to identify the best water treatment solutions. For example over the last 5 years in South Sudan there has been a number of Hepatitis E outbreaks therefore having a filter that eliminates viruses is important.

From previous research, it is safe to say that the success of any household filter programme is dependent on the number of follow up visits[1]. This research does not take this into account nor the amount of families who continued to use their filter for over 6 months which is also a good indicator of acceptance and ease of use (HOLDING, 2017).

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References

TWiG Technical Working Group, South Sudan WaSH Cluster 2016 *Water Filter Findings*.

LEMONICK, DM, 2011 *Epidemics After Natural Disasters.* MD, FAAEP, FACEP. American Journal of Clinical Medicine• Fall 2011 • Volume Eight, Number Three.

WATSON, J.T., GAYER and M.CONNOLLY, M.A. 2007 *Epidemics after Natural Disasters* Emerging Infectious Diseases Vol. 13, No. 1, January 2007.

EM-DAT: The Emergency Events Database - Universite catholique de Louvain (UCL) - CRED, D. Guha-Sapir –

HOLDING, S. SADEGHI I., WHITE, T. MURRAY, A. RAY, J. ASATEKIN, A. and LANTAGNE D. 2017 A*cceptability, Effectiveness, and Fouling of Household Membrane Filters Distributed in South Sudan.*

KOUADIO, I.K. ALJUNID, S. KAMIGAKI, T. HAMMAD, K. and OSHITANI, H. 2012 *Infectious diseases following natural disasters: prevention and control measures.* Expert Review of Anti-infective Therapy, 10:1, 95-104, DOI: 10.1586/eri.11.155.

BRUCKNER, C. and CHECCHI F. 2011 *Detection of infectious disease outbreaks in twenty-two fragile states, 2000-2010: a systematic review.* Conflict and Health 2011 5:13.

HAKIM, M.S. WANG, W. BRAMER, W.M. GENG, J. HUANG, F. DE MAN, R.A. PEPPELENBOSCH, M.P. and PAN, Q. 2016 *The global burden of hepatitis E outbreaks: a systematic review.* Wiley. Lever International.

GHDX, *GBD Results Tool*, URL: http://ghdx.healthdata.org/gbd-results-tool?params=gbd-api-2016-permalink/fd774524976e249d60d5df78c631dc79 access on 8th of February 2018.

WHO, *rotavirus deaths by country 2000-2013*, URL: http://www.who.int/entity/immunization/monitoring_surveillance/rotavirus_deaths_by_country_2000-2013.xlsx?ua=1 access on 8th of February 2018.

Note/s

[1]Personal communication between Andy Bastable, Oxfam and Daniele Lantagne, Tufts University.

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