HUMANITARIAN INNOVATION FUND
Final Report

Organisation Name	Artsen Zonder Grenzen / MSF-Holland

Project Title	Safe Water for Refugees
Problem Addressed / Thematic Focus	Evidence-based guidelines for safe water supply in humanitarian operations
Location	**Azraq Refugee Camp, Jordan** **Kigeme Refugee Camp, Rwanda**
Start Date	15/2/2015
Duration	Agreement expires 31/10/2015
Total Funding Requested	£19,275

Partner(s)	**United Nations High Commissioner for Refugees (UNHCR)** **UC Berkeley**
Total Funding	HIF contribution sought: £19,275 UC Berkeley/UNHCR contribution: £20,226

Innovation Stage	Invention
Type of Innovation	Service and process
Project Impact Summary	The evidence base underlying current emergency safe water guidelines is essentially non-existent. In fact, guidelines for free residual chlorine (FRC) in refugee/IDP camps—intended to protect water supply from pathogenic recontamination—are based on conventions for municipal piped-water systems, a context fundamentally dissimilar to the camp setting. We observe in refugee camps in South Sudan that post-distribution FRC decay can be so rapid that, in effect, there is no safe water in refugee households. This entails serious consequences for public health. There is an urgent need

	to develop evidence-based guidance for emergency safe water supply that is grounded in the realities of crisis settings. The *Safe Water for Refugees* project launched research in multiple refugee/IDP camps globally, in diverse environmental contexts, in order to build this much needed evidence base. We carried out observational studies investigating water quality, water-handling practices, and contextual factors at the Azraq refugee camp, Jordan (winter/spring 2015), and at the Kigeme Refugee camp, Rwanda (summer 2015). These studies built upon earlier work carried out in South Sudan (spring 2013) and Jordan (summer 2014.) Multiple manuscripts to disseminate key findings to the wider humanitarian and academic communities are in preparation that will together form a series including: 1. Seasonality and chlorine decay in emergency water supplies: Comparing water quality data from multiple seasons at Azraq refugee camp, Jordan. 2. Evidence-based emergency water treatment guidelines: Integrating water quality data from refugee camps in South Sudan, Jordan, and Rwanda to produce operational guidance for emergency responders. 3. Water handling practices and protecting the safe water chain in refugee/IDP camps: Exploring associations between water quality and water-handling practices from refugee camps in South Sudan, Jordan, and Rwanda to produce operational guidance for emergency responders. Key recommendations for field practice from the manuscripts above will be collated in an operational guidance document for MSF and UNHCR in order to directly influence humanitarian field operations and improve the way safe water is delivered in refugee/IDP camps the world over.

Reporting Period	15/2/2015 – 31/10/2015

Total Spent	£12,795

PROJECT ACTIVITIES AND OUTPUTS

What have been the key achievements of the project?

The evidence base underlying current emergency safe water guidelines is essentially non-existent. In fact, guidelines for free residual chlorine (FRC) in refugee/IDP camps—intended to protect water supply from pathogenic recontamination—are based on conventions for municipal piped-water systems, a context fundamentally dissimilar to the camp setting. We observe in refugee camps in South Sudan that post-distribution FRC decay can be so rapid that, in effect, there is no safe water in refugee households. This entails serious consequences for public health. There is an urgent need to develop evidence-based guidance for emergency safe water supply that is grounded in the realities of crisis settings.

The *Safe Water for Refugees* project launched research in multiple refugee/IDP camps globally, in diverse environmental contexts, in order to build a much needed evidence base. We carried out observational studies investigating and linking water quality, water handling practices, and contextual factors at the Azraq refugee camp, Jordan during late winter/spring 2015, and at the Kigeme Refugee camp, Rwanda in summer 2015. These studies built upon earlier work carried out in South Sudan in spring 2013 and in Jordan during summer 2014. While not exhaustive, these sites are representative of some of world's major on-going displacement crises (Sahel: South Sudan; Middle East: Jordan; Great Lakes Region: Rwanda). **The research has yielded several important insights:**

- Current FRC guidelines appear to offer insufficient protection in refugee/IDP camp settings with high temperatures and poor ambient hygienic conditions. Therefore, FRC targets at tapstands may need to be increased from the current 0.2–0.5 mg/L range up to the 0.5–1.0 mg/L range, irrespective of pH/outbreak conditions, at all locations.
- Temperature, ambient environmental hygiene, initial FRC levels at tapstands, and sunlight exposure are major drivers of post-distribution chlorine decay. Therefore, guidance tables articulated with respect to: i) local climate; ii) ambient environmental hygiene; iii) desired duration of household water protection (e.g., 12 hours, 24 hours); and iv) desired level of FRC protection at "last cup" consumption would be more useful than the uniform global rule that is presently used. Moreover, even at a given site, seasonal adjustments of chlorination targets may be necessary due to temperature-driven fluctuations in chlorine decay.
- This is the first study to investigate chlorine decay post-distribution in *any setting* and therefore has implications not just for emergency water

systems in refugee/IDP camps but also for the intermittent water systems that are increasingly the norm in developing countries (i.e., findings may also be applicable in slum settings with irregular water supply).

With the evidence this project has generated, we will produce the first ever evidence-based guidelines for centralized batch chlorination in humanitarian operations. Our project will improve how safe water is delivered in refugee/IDP camps the world over by revising UNHCR, MSF, and Sphere Project guidelines (publications currently in preparation; discussed further in the "Dissemination" section below). By improving safety of camp water supplies, this project will help reduce the burden of diarrhoeal and other waterborne diseases in refugee/IDP camps, diseases which remain among the primary threats facing displaced populations.

What were the major activities and outputs of the project (this may include a description of the activities conducted and how they related to the work plan)?

The major activities of this project were two field research trips of approx. two months each at the Azraq refugee camp, Jordan (March-April 2015) and the Kigeme refugee camp, Rwanda (June-July 2015). These trips produced a large dataset on refugee camp water quality that builds on earlier work performed in South Sudan during spring 2013 and in Jordan during summer 2014. In addition to water quality monitoring, we also documented water-handling practices in order to identify practices that compromise or, alternately, preserve the safe water chain. Multiple manuscripts and conference presentations to document project outputs and disseminate findings to the wider humanitarian and academic communities are in preparation and will help shape humanitarian field operations in future. These outputs are detailed in the "Dissemination" section below.

What adjustments and adaptations were made through the course of the project? Why were these needed and how were these made?

Two amendments were made during the course of this project:

1. **Site amendment:** The original locations in the Agreement were Gambella, Ethiopia and Betou, Congo-Brazzaville. A site amendment request was submitted in June 2015 to modify these to the Azraq refugee camp, Jordan and the Kigeme refugee camp, Rwanda. Azraq was selected because we undertook research work at this camp in summer 2014 (prior to being awarded the HIF grant). In discussion with research partner UNHCR, we decided to return to the Azraq camp again in late winter/spring 2015 in order to investigate seasonality effects on water quality (i.e., same camp, different season). We decided to replace Gambella, Ethiopia with Kigeme, Rwanda on the grounds it was too similar with respect to climate and environment to South Sudan, where we had originally launched the research in 2013. One of the key

determinants in site selection was to choose sites representing unique climactic settings in which there are on-going displacement crises. With UNHCR, we determined that Rwanda was the best option given its accessibility, the uniqueness of its climactic setting, and most useful given the current displacement crises in the Great Lakes Region (e.g., Burundi and DRC).

2. **Budget and duration amendment:** We submitted a budget/duration amendment in August 2015 to re-allocate unspent funds from line item C9 Accommodation (under the PERSONNEL heading) of the original budget to: 1) Line item B1 "Shipping" under the LOGISTICS heading to cover unforeseen shipping costs; and 2) Line item D2 "Conference costs" under the OTHER heading to support an additional dissemination activity. Savings were found on line item C9 Accommodation as we had originally budgeted £60 per night for 120 nights in a basic hotel at the Jordan and Rwanda field sites (for a total of £7200). We achieved savings here by instead arranging accommodations in long-term rentals at Jordan and Rwanda. Only £1782 GBP was spent in total on accommodations during field research, for a total savings of £5418 GBP on the accommodation line item. We therefore sought to reallocate funds: 1) to cover unforeseen logistics-related expenses for shipping research equipment to Jordan and Rwanda; and 2) to support an additional dissemination activity—a research presentation at the *6th Emergency Environmental Health Forum* in Nairobi (October 16-17, 2015) including return flight (San Francisco-Nairobi); accommodation in Nairobi; airport transfers; and Kenyan visa fees. In addition, since the grant agreement was set to expire on 15/9/2015, we requested a NCE to the project to extend it until 31/10/2015 to allow us to present at the Nairobi conference in October.

Please explain any budget various greater than 15% of the original budget headlines

- Travel/Accommodation Costs: Major variance in this category was in savings found on Field Accommodations as we had originally budgeted £60 per night for 120 nights in a basic hotel at the Jordan and Rwanda field sites (for a total of £7200). We achieved savings here by instead arranging accommodations in long-term rentals at Jordan and Rwanda. Only £1740 GBP was spent in total on accommodations during field research, for a total savings of £5459 GBP on the accommodation line item. As per Budget/Duration Amendment, part of these funds were reallocated to support a dissemination activity: a presentation at the 6th Inter-Agency Emergency Environmental Health Forum in Nairobi (Oct 16-17, 2015). The remaining savings in this category were used to offset excessive logistics costs as per the Budget Amendment.
- Activity Costs: Major variances in this category include savings of £1349 with the Palintest chlorometer/turbimeter kit of which only one was required because research partner MSF already had one available for use in the field. The other major variance occurred with respect to logistics

for the temporary importation of research equipment into the field sites. We had previously hand carried equipment to the field but were unable to do so on this occasion due to the large volume of material so it had to be shipped and was therefore subject to customs taxes and levies for temporary importation.

- Publication Costs: The manuscripts produced by this research are still in preparation so we were not been able to submit for publication before the end of the grant period, hence the open-access publication costs was unused for this purpose (£814).
- Overhead: MSF did not take overhead from this grant so this portion was unused for this purpose (£1261).

INNOVATION OUTCOMES

What were the outcomes of the project (positive or negative) and how did these follow from activities and outputs described above?

At present, there is a complete absence of field evidence undergirding emergency water treatment practices. In fact, we in the humanitarian sector have little documented insight into how well any of our interventions actually work in the field. This project was the first systematic investigation of a core WASH function in the field. It has produced valuable data that will be used to develop evidence-based guidelines that are appropriate and effective for emergency settings.

Has the project demonstrated the success of the innovation?

The research work of this project was observational in nature, intended to generate a primary evidence base on water quality in refugee/IDP camps. We observed chlorine decay in water supplies going from distribution (i.e., tapstand) to consumption (i.e., household). From this, we determined what FRC levels must be in order to protect water supply for the entire duration of its household storage and use in a variety of climatic/environmental contexts. This will be presented in evidence-based FRC guidance tables, now under development on the basis of these field data. The study was not experimental in nature however as at both Azraq and Kigeme camps chlorination levels at the tapstands were already elevated with respect to standard FRC guidelines (i.e., >0.5 mg/L) and within the evidence-based target range (as determined on the basis of field data at each specific camp). Therefore, the effectiveness of evidence-based FRC targets is implicitly documented within the data and embodied in the evidence-based guidance, but we did not carry out an experimental trial at either of our field sites as we were primarily operating in an observational mode.

If yes, what evidence is there for the performance of the innovation?

In principle, chlorination is well established as an effective water treatment method. The gap this project addressed is that we do not have data on the

effectiveness of current FRC guidelines in emergency settings. We collected data on chlorine decay across a wide range of initial concentrations and time duration of household storage and use, which allowed us to determine what levels of initial FRC concentration are actually protective at a desired time post-distribution, in a variety of conditions. The new evidence-based guidelines being developed with these field data will help improve the performance of chlorination systems in refugee/IDP camps around the world.

If no, what are the key lessons about the innovation or area of practice?

The research and innovation process was successful.

Do the outcomes support the initial rationale for the innovation?

At both field sites, we found that FRC levels in line with current guidance (0.2-0.5 mg/L) did not offer sufficient protection for the entire duration of household storage and use. In fact, we often observed that water system operators were, on an ad hoc basis, increasing FRC levels at tapstands over the guideline levels on a trial and error basis to improve water safety. This project has now generated field evidence on chlorine decay that can be used to justify an increase/modification of the published FRC guidelines. Additionally, we found that in settings where temperatures are high and ambient environmental hygiene is poor (i.e., South Sudan), chlorine decay is rapid and sufficient chlorine residual can only be maintained for up to 10 hours post-distribution. This may indicate:

1. Water should be supplied at more regular intervals in these camps (i.e., <12 hours) so that stored water does not become unprotected and liable to be re-contaminated; or,
2. Chlorination alone is not sufficient to ensure water safety in these settings and other forms of treatment at the household or central level may also be required.

In other settings that were cooler and had better ambient environmental hygiene (i.e., Jordan and Rwanda), adoption of new evidence-based FRC targets should be able to maintain water safety for up to 24 hours in most cases.

How has your understanding of the innovation changed through the project period?

We encountered at the Azraq refugee camp an unexpected water management practice by refugee households. Because the refugees were largely from rural Syria and were accustomed to high quality groundwater sources, they found the chlorine taste and odour in the camp water supplies to be highly objectionable. Possibly in response to excess chlorination events we documented (i.e., >1.0 mg/L), refugee households took to storing chlorinated water in direct sunlight.

This was a highly effective method for driving off chlorine, reducing FRC to almost nil in just a few hours. What this underscored for us was:

1. The importance of effective chlorination management in camp water systems excess chlorination events can drive widespread rejection of treated water supply and drive camp residents to turn to other potentially unsafe sources of water or practices to drive off chlorine protection in treated water; and
2. Chlorination may sometimes be unsuitable for populations with low acceptance of chlorine taste/odour if their rejection threshold is less than the FRC level required to provide sufficient protection of their water.

Did the innovation lead to any unexpected outcomes or results? How were these identified and managed?

One important unexpected outcome of this research has to do with what is generally considered as "safe" water. Generally, it is assumed (and this assumption is embodied in the humanitarian guidelines as well) that if FRC is detectable, pathogens are not present and the water is microbiologically safe for consumption. However, as we have often seen in the sector, we lack an actual evidence base that demonstrates the validity of this assumption. Conceptually, at some FRC level, the disinfection process must become reactant limited such that there may be low levels of residual chlorine *and also* microbes—potentially pathogens—existing in the same water. In light of this, and motivated by the imperative to prove water safety, we also included in our study a microbiological component focusing on household water samples. At the former, we found no evidence of microbiological contamination at the household level, possibly due to the very high levels of ambient environmental hygiene at the camp. However, at the latter camp, we observed both *E. coli* contamination and low residual chlorine levels (i.e., less than or equal to 0.10 mg/L)! This undermined the assumption we generally make about water safety—that if there's detectable chlorine, there can be no microbiological contamination. This rather unexpected finding underscores the need to ensure a minimum of 0.2 mg/L FRC "until the last cup" in order to ensure water safety—in all settings, be it emergency or a stable context.

What are the key lessons learnt relating to the innovation (this should relate to the innovation itself, rather than project implementation)?

Presenting this research at the *Emergency Environmental Health Forum* in Nairobi in October provided us an opportunity to seek important feedback from all of the major emergency WASH agencies operating today. One of the concerns noted with respect to our general recommendation to increase FRC levels at tapstands was the associated risk of taste/odour-driven rejection of treated water. Agencies had anecdotal evidence of this, but the discussion at the conference made clear that this threshold is highly variable across populations and that there has been no systematic research to determine what chlorine acceptance/rejection thresholds are for various displaced populations. While the

current research had addressed what was the minimum FRC required to protect camp water supplies, this was only half the problem: the other half is to understand what is the maximum FRC before rejection occurs.

METHODOLOGY

Was the methodology successful in producing credible evidence on the performance of the innovation?

With respect to chlorine decay and water quality, we used laboratory analysis devices and a multi-step data collection process that produced high-density data at a range of time points post-distribution. The study methodology was originally developed in South Sudan in 2013 and iteratively refined, including adopting new analytical equipment in Jordan in 2014, so the methodology was well-refined by 2015 when we returned to Jordan and advanced to Rwanda. Altogether, the research has generated a large volume of high quality data that we will use to develop and justify new evidence-based FRC guidelines. On the other hand, we used spot observations and respondent self-reports to document water-handling practices so the data generated here is less reliable. Indeed we found inconclusive or only weak evidence on the effectiveness of standard hygienic water practices (i.e., cleaning containers, using a tap, using covered containers), possibly owing to the inability of these methods to accurately capture the multiplicities of practices in reality. More rigorous methods (i.e., structured observations) would be required to accurately capture water-handling practices that were not the focus of the present research so ultimately not pursued.

What adjustments were made to the methodology during the course of the project? Why were these needed and how were they made?

Originally our data collection protocol indicated four unique water quality analysis events:

1. Directly from the tap at the tapstand i.e., at the *point of distribution*;
2. From respondents' containers immediately after collection at the tapstand;
3. From respondents' containers after transport to shelters; and
4. From respondents' containers after approximately 6 to 24 hours of household storage and use i.e., at the *point of consumption*.

We found however that the most valuable data for our purposes was toward the end of the period of household storage and use. Therefore, in the Rwanda iteration of the study we included an additional water quality analysis event at the household level for a total of five unique water quality analysis events. This helped us to better constrain our modelling of FRC decay and produced additional valuable data on chlorine decay at late time points post-distribution.

PARTNERSHIPS AND COLLABORATION

Describe the partnership arrangements and how these may have changed during the course of the project.

This project was a partnership between UC Berkeley, MSF-OCA, and UNHCR. Originally, UC Berkeley was to be the recipient of the grant but due to institutional barriers at the university that prevented the timely receipt of funds, MSF-OCA stepped in as the recipient organization. MSF-OCA was the originator of the research in South Sudan and a research partner in expanding it to other camps globally. UC Berkeley provided in-kind support by covering lead researcher salary for the field research period. UNHCR had the role of facilitating access to field sites in addition to providing in-kind support in the form of field transportation and field staff salaries.

DISSEMINATION

Indicate the steps taken to disseminate the outcomes of the project.

What dissemination activities have or will be conducted (whether or not included in the budget)?

What publications have resulted from the project, or are forthcoming (i.e. research and policy reports, journal articles, case studies, evaluations etc.)?

{Addressing all three questions above in the passage below}

Multiple manuscripts to disseminate key findings to the wider humanitarian and academic communities are in preparation. These publications build on an earlier article published in the *Bulletin of the World Health Organization* that reports early findings from South Sudan (prior to the initiation of this HIF grant) and will together form a series that includes:

4. Seasonality and chlorine decay in emergency water supplies: Comparing water quality data from multiple seasons at Azraq refugee camp, Jordan.
5. Evidence-based emergency water treatment guidelines: Integrating water quality data from refugee camps in South Sudan, Jordan, and Rwanda to produce operational guidance for emergency responders.
6. Water handling practices and protecting the safe water chain in refugee/IDP camps: Exploring associations between water quality and water-handling practices from refugee camps in South Sudan, Jordan, and Rwanda to produce operational guidance for emergency responders.

Key recommendations for field practice from the manuscripts above will be collated in a separate **operational guidance document** for MSF and UNHCR in

order to directly influence field operations in the humanitarian sector. Further conference presentations may take place in 2016 pending funding availability.

To date, a number of preliminary documents and dissemination activities have already been produced including:

- UNHCR consultancy report summarizing findings of Jordan 2015 field study.
- UNHCR consultancy report summarizing findings of Rwanda 2015 field study.
- Presentation of key findings from South Sudan, Jordan, and Rwanda studies to wider humanitarian community at the *6th Inter-Agency Emergency Environmental Health Forum* (Nairobi, Kenya, Oct 16-17, 2015).
- Presentation of key findings from South Sudan, Jordan, and Rwanda studies to wider academic community at the *2015 Water and Health Conference: Where Science Meets Policy* (University of North Carolina, Chapel Hill, Oct 26-30, 2015).

Has the project received any third party coverage during the project (from news media, third party blogs, researchers or academics etc.)?

None during the HIF project period (2015).

TRANSFERABILITY

Please indicate if there is any potential to replicate the project and how.

There is no plan to replicate the project at present however we do intend to build upon on it by launching a new study to investigate the other side of the chlorination puzzle—what are chlorine acceptance/rejection thresholds for different displaced populations? This project is currently in development in collaboration with UNCHR and Tufts University.

What are the plans for scale-up beyond the pilot?

Key recommendations for field practice from the manuscripts above will be collated in a separate **operational guidance document** for MSF and UNHCR in order to directly influence field operations in the humanitarian sector. These will also be presented to the Sphere Project in order to advocate for a revision of the Sphere water treatment guidelines. Through these avenues, the project will inform humanitarian practice and policy.

Are any other organisations planning to use or adapt the innovation?

UNHCR and MSF, as partners on this research, recognize the problem and are invested in solving it. They intend to adopt the outcomes of the research as documented in the forthcoming operational guidance documents. In the wider sector, discussions at EEHF in Nairobi this year indicate that other WASH agencies similarly recognize the problem and will adopt the innovation, especially with additional research on taste/odour thresholds to complement the current findings.

What steps have been taken to ensure the transfer of the innovation and the learning from the project?

Operational guidance documents have been requested by partners UNCHR and MSF in order to improve their field operations on the basis of project findings. Further advocacy by HIF, MSF, and UNCHR will help extend the outcomes of the research to the sector at large. Targeting the Sphere Project will be especially important for this.