CERAMIC FILTERS FOR IMPROVING WATER QUALITY

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Ceramic Filters For Improved Water Quality

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Please note that this report looks different to our other reports as it was written by participants of our Research Training Program. This report was conducted within Charity Entrepreneurship's Research Training Program in the fall of 2023.

Thanks to Erik Hausen and Leonie Falk for their contributions to this report. We are also grateful to the experts who took the time to offer their thoughts on this research.

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Executive summary

In 2022, **one in four** people did not have access to clean drinking water. For example, in the same year, at least **1.7 billion people** worldwide used drinking water sources contaminated with feces. This is a major health risk, causing more than **a million deaths** each year.

Moreover, lack of access to clean water is the leading risk factor for many infectious diseases, including diarrhea and cholera. It also exacerbates other health issues such as malnutrition and, in particular, childhood stunting.

The solution we propose is straightforward and has been shown to have a strong protective benefit on the incidence of diarrhea in under-5s and adults. It involves manufacturing and distributing free ceramic water filtration devices in low-income settings.

Various randomized controlled trials, including a meta-analysis from Cochrane, support using ceramic water filters to reduce the burden of diarrheal disease. These studies find that the use of these filters can reduce episodes of diarrhea in low- and middle-income countries by an estimated **34-71%**. In 2019 alone, diarrheal disease is estimated to have killed 1.5 million people, which is more than tuberculosis or malaria. 0.5 million of these deaths were in children under the age of 5.

**There is room for a new organization working in the space.** Most existing filtration efforts are small and locally-led. This means that there are many countries and regions that are not covered by existing work and would benefit greatly from a new charity providing free filters. Our geographic assessment suggests that a new charity could be most promising in Nigeria, Burundi, Cameroon, Eritrea and Mali. Only Nigeria has an existing organization working there, and they by no means have the whole country covered.

**This intervention is expected to be highly cost-effective and can reach people in more deprived areas.** It is expected to be similarly cost-effective as other water quality interventions (such as chlorination) with an average estimated cost-effectiveness of $77 per DALY (ranging from $15-$118 depending on the country modeled), yet it does not need there to be as much existing infrastructure such as water piping or reliable supply chains, and as such can reach people in more deprived areas.

**There are a number of considerations and uncertainties that founders working on this idea would need to work through.** Different water treatment solutions affect different pathogens. Ceramic water filters stop bacteria and protozoa but not viruses,
whereas chlorination kills bacteria and viruses but not protozoa. This means that in some cases where there is a higher prevalence of viruses, it would be more appropriate to use chlorination rather than ceramic filters. Founders should consider the burden caused by different pathogens when choosing a location to work in. Also, this intervention may need an RCT fairly early on. The current evidence base only measures the reduction in episodes of diarrhea from ceramic water filter use, so it would be beneficial to demonstrate more directly the effect on child mortality.

**Overall, we believe this is an idea worth recommending for incubation.** Addressing the burden of unclean drinking water is a global health priority. We think that the provision of free ceramic water filters will significantly aid in achieving this goal at a low cost and can reach populations that might be missed by existing water quality interventions, such as chlorination.
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1 Introduction

This report was conducted within Charity Entrepreneurship's (CE's) Research Training Program in the fall of 2023.

This report evaluates the promise of promoting Ceramic Water Filters For Improved Water Quality. This intervention was chosen by CE's research training program participants as a potentially promising intervention. This decision resulted from a two-week process to identify interventions that were most likely high-impact avenues for future charity entrepreneurs.

This process began by listing 40 ideas, gradually narrowing them down, and examining them in increasing depth. We use various decision tools such as evidence reviews, theory of change assessments, group consensus decision-making, case study analysis, weighted factor models, cost-effectiveness analyses, and expert inputs.

This process is exploratory and rigorous but not comprehensive – we did not research all ideas in depth. As such, our decision not to take forward a non-profit idea to the point of writing a full report does not reflect a view that the concept is not good.

In this report, we evaluate whether ceramic water filters can be an evidence-backed, cost-effective way to prevent deaths and improve the quality of life in countries where there is low access to quality water. We first present some background information (Section 2) and a Theory of Change for how this could work in practice (Section 3). We then investigate the existing evidence that may support this intervention's effectiveness (Section 4) and report expert views from people who have already implemented similar theories of change (Section 5). We follow on to assess in which countries this should be a priority (Section 6), report our cost-effectiveness estimates (Section 7) and evaluate the implementability of this idea for a new charity (Section 8). Finally, we provide some final conclusions (Section 9).
2 Background

2.1 Burden of Diarrheal disease due to inadequate water intake

According to the World Health Organization, in 2022, at least 1.7 billion people in the world consumed drinking water from a source contaminated with feces. The resulting microbial contamination of drinking-water is deemed among the greatest risks to drinking-water safety (WHO, 2023). The risks of illness or death from unsafe water are particularly high for children in low-income settings, relative to other age groups (GiveWell, 2022). In 2019 alone, diarrheal disease is estimated to have killed 1.5 million people, 0.5 million of which were under the age of 5 (Global Burden of Disease, 2019). For comparison, tuberculosis is estimated to have killed 1.6 million, and malaria is estimated to have killed 0.6 million people in the same year.

2.2 Possible water quality interventions

Many different water quality improvement interventions exist to tackle the issue of contaminated water. These include chlorination mechanisms (GiveWell, 2022), water filtration systems such as ceramic filters, biosand systems, lifestraw filters, plumbed-in filters (Clasen et al 2015), water filters, and natural draft rocket style cookstoves (Kirby et al 2019), and high-performance water filter and jerry cans for safe storage (Peletz et al 2012).

We considered these options and ultimately decided to focus on ceramic filtration as our proposed intervention. This was due to various reasons:

1) The charity evaluator GiveWell has already extensively studied the cost-effectiveness of chlorination devices and supports Evidence Action's chlorination programs (GiveWell, 2022), and we did not want to duplicate their efforts.

1 More specifics can be found in our Evidence Review Spreadsheet - Comparing water quality solutions tab, which covers other purification/filtration methods. Other Water, Sanitation and Hygiene (WASH) interventions tackling sanitation or of a more educational/behavioral nature have not been separately investigated in this report.
2) There is the potential that these alternative water purification techniques, such as ceramic filters, can be more cost-effective than chlorination. It is worth exploring this as a potential intervention idea.

3) Out of the alternative water purification techniques, we found ceramic filters to be the most promising in terms of cost and ease of installation, operation, and maintenance.

### 2.3 What are ceramic filters?

Point-of-use ceramic water filters consist of a porous ceramic element and a recipient for the filtered water. The tiny pores of the ceramic are small enough so that contaminants like bacteria, protozoa, and sediment cannot physically pass to the recipient. Manufacturers usually also add colloidal silver to the ceramic, which enhances the filter's effectiveness by acting as a biocide, preventing the (re)growth of microbes on the surface of the filter (Woodard, 2023).

In this report, we have considered two types of ceramic filters mentioned in the Unicef (2022) product guide: the “bucket + pot” design and the “bucket + candle(s)” design.²

![Figures 1(a) and 1(b)](image)

**Figures 1(a) and 1(b)** - (a) Image of a bucket + pot ceramic filter available for sale in Rwanda and Uganda and (b) a diagram of its internal anatomy (Spouts of Water, n.d.).

These filters are a reliable method for improving water quality and preventing enteric diseases from some pathogens – bacteria and protozoa – but they are not effective against viruses. While the maintenance they require is usually minimal, they do require

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² We double checked the references included in the main systematic review considered for this report (Clasen et. al, 2015) to make sure they did not mistakenly label other water treatment strategies (membrane filters, multi-step or biosand filters, solar disinfection etc.) as ceramic filters.
regular cleaning to prevent clogging. Moreover, their ceramic composition makes them fragile and heavy to transport, and they can be prone to cracking or breaking if not handled with care.
3 Theories of change

This report focuses on interventions designed to manufacture and distribute free ceramic water filtration devices in low-income settings. We consider two versions of this model: providing ceramic filters with minimal education, and providing ceramic filters with WASH Education.

The key distinction between these interventions is the extent of educational support. The minimal education model focuses on instructing users about the setup, usage, and maintenance of ceramic filters. The WASH Education model offers a more comprehensive educational package, aligned with methodologies observed in related studies. This broader education might cover topics such as nutrition (including food preparation and maternal-child nutrition), hygiene practices (such as handwashing with soap), and safe water handling. While this report does not specify the exact content of WASH education, it aims to assess its potential additional benefits and costs relative to the minimal education approach.

The following is the detailed theory of change (ToC) for this idea:

Figure 2 - Theory of Change (ToC) for an intervention that distributes free ceramic filters.
We provide an assessment of each causal pathway and our confidence in it below:\(^3\)

1. **It is necessary for a new organization to manufacture its own filters, rather than procuring them, as they are fragile and cannot be transported long distances.**

   We think that it is **likely (65-80% confidence)** that a new organization will be able to manufacture high-quality ceramic filters locally. This is because there are many organizations that have already implemented a similar program, which we take as proof of concept. These organizations, where they work, and their activities are detailed in [Section 6.1].\(^4\) We assume that a new ceramic filter will need to be provided every 2 years based on our literature review and expert views ([Unicef, 2020](#)); ([Potters Without Borders, n.d.](#); see [Section 5]).

   We also think that it is **likely (65-80% confidence)** to be logistically possible to deliver these ceramic filters at the household level. This assumes that we will be able to adequately pack them such that they do not get damaged, that there will be adequate road conditions, and an available workforce. This is because we have seen many existing organizations and studies that have provided free ceramic filters to households in LMICs which provides us with confidence that this is logistically possible. Michael Anyekase (see [Section 5](#) highlighted that long distances, bad road conditions, inexperienced truck drivers, and lack of knowledge of how to properly cushion the filters are all important factors that can lead to high breakage rates during transportation. We think that these factors are important for founders to keep in mind when choosing a location for the factory and to monitor once the factory is set up and deliveries start being made.

   We currently recommend free provision of ceramic filters as the best option, but there is potential that offering them at a subsidized price would be more cost-effective. While charging for water filters could offset some charity expenses and people may be more willing to take care of or use something they paid for, we think it more likely that the target population will be unwilling to pay

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\(^3\) Each bullet point number relates to the circles in the ToC figure.

\(^4\) These articles showcasing Pure Home Water’s work are also particularly insightful ([1](#)), ([2](#)).
for filters, even if it was a subsidized price. The ultimate choice of model should be deeply informed by local culture, consumer behaviors, and drinking water practices.⁵

2. **Households understand the instructions provided by the charity on how to use ceramic filters.**

We have very high confidence (80-95%) that a charity would be able to provide easily understandable instructions on how to correctly use these filters. In addition, ceramic filters are relatively simple and likely intuitive to use compared to other water filtration devices we compared (see full discussion in Section 4.1). This means that instructions should be easy and simple to follow.

3. **Households understand the importance of WASH after reading leaflets or attending training/seminars provided by the charity.**

It is unclear whether information provision alone on WASH would increase the motivation and capability of households to actually use their ceramic water filter or perform other hygienic behaviors.

URL (1995b) suggests that adding a WASH education component to the provision of ceramic water filters increases the average reduction in diarrhea episodes by an extra 12 percentage points or 22% of the effect size. We discuss this further in Section 4.2.

Note that the lines here are dashed as the intervention does not necessarily have to include broader WASH education. This should be a decision made by the co-founders of a new charity.

4. **Households use the ceramic filters consistently**

We think that it is likely (65-80% confidence) that household will use the provided ceramic filters consistently. A Cochrane review sheds light on the adherence rates⁶ of ceramic filter usage (Clasen et. al., 2015). Across 9 randomized controlled trials (RCTs) included in the analysis, the average adherence for ceramic filter use was 87% (2 of them measured through water quality measurements; 4 through self-report; the remaining measurement methods are unclear). Adherence rates varied within these trials (ranging from

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⁵ We recommend conducting this research during country scoping visits.

⁶ Here adherence means using ceramic filters correctly and consistently for all drinking water, as intended.
55% to 100%), but overall they suggest households consistently use (or report using) ceramic filters. 7 out of the 9 RCTs had adherence rates exceeding 87%. Notably, the average adherence rate for ceramic filters surpasses the adherence observed in other water quality interventions within the same meta-analysis. For instance, the average adherence for chlorination devices was 61%, with a range from 32% to 90% across 13 RCTs. For additional details, see our Evidence Review Spreadsheet, tab “Uncertainty about adherence”.

To determine whether or not community members were using the ceramic filters correctly, we can also look at the Risk Ratios (RR) of episodes of diarrhea in those in the treatment arm compared to those in the control group in Clasen 2015. Overall, the RR of episodes of diarrhea in the treatment arms (CF devices provided) across all studies was 0.39 (95% CI: 0.29 - 0.53) (p.123). This indicates that ceramic filters reduced the risk of contracting diarrhea by 61% relative to those without filters, which suggests that households were using the ceramic filters correctly (see full discussion in Section 4.2).

However, we do have some uncertainties regarding whether there are cultural norms or behaviors that would limit the adoption and consistent/proper use of ceramic water filters. For example, expert Michael Anyekase (see Section 5) noted behavioral challenges as potential impediments to the adoption of ceramic water filters (together with cost). More specifically, he mentioned a “My parents drank unclean water and survived“ mentality from many people, implying that individuals do not necessarily see the benefits of cleaner drinking water.7

We highlight that adherence in using the ceramic water filters will play a large role in the overall impact of this intervention and so this is something that those working on this should keep at the top of their minds and monitor closely. If adherence is low then you will need to come up with ways to increase adherence through accountability mechanisms and/or incentives.

5. Households use the ceramic filters correctly

We think that it is very likely (80–95%) that households will use filters correctly. Ceramic filters are relatively simple and likely intuitive to use compared to other

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7 We propose the following as good research questions to follow up with: “Will people use these filters if provided?”, and “Do people perceive the time and effort required for using ceramic filters as worthwhile for obtaining cleaner water?”. These questions are best answered in relation to specific countries prioritized in through our proposed geographic weighted factor model.
water filtration devices we compared (see full discussion in Section 4.1). We also think that our instructions on filter use will go a long way. Also, expert interviews we conducted do not mention difficulties in understanding how ceramic filters work as one of the behavioral impediments to further adoption (see Section 5).

6. Ceramic filters are effective at cleaning water

It is clear that ceramic filters are effective at cleaning water. A Cochrane Review (Clasen, 2015, p.123) concludes that the RR of episodes of diarrhea in the treatment arms (where ceramic filter devices are provided) was 0.39 (95% CI: 0.29 - 0.53). This indicates that ceramic filters reduced the risk of contracting diarrhea by 61% relative to those without filters.

Ceramic filters have been independently assessed for pathogen removal by the World Health Organization, with three out of four products achieving the “targeted protection” standard (99% removal against bacteria and protozoa) (WHO, 2019a). They have not been evaluated against viruses, though, since ceramic filters are not adequate against this type of pathogen (Unicef, 2020).

We assume that ceramic filters have a lifespan of two years. Among the RCTs we examined, the longest follow-up period was only one year. In an ideal scenario, we would have access to evidence demonstrating the effectiveness of ceramic filters over longer periods.

7. Cleaner drinking water leads to decreased diarrhea and other waterborne illnesses

It is clear that clean drinking water decreases the incidence of diarrhea and other waterborne illnesses. Currently 502,000 diarrhoeal deaths in LMICs can be attributed to inadequate drinking water (GiveWell, 2022; WHO, 2014).

8. Preventing diarrhea leads to significant improvements in health outcomes

Improved water quality and reduced diarrhea has mortality impacts, morbidity impacts, development effects, and averts medical costs (GiveWell, 2022; WHO, 2023).

The mortality effects can be seen as two-fold: reduction in diarrheal mortality and a reduction in all-cause mortality. The reduction in diarrheal mortality is the most clear and well understood, but this doesn’t seem to account for all of the
mortality reduction. You can read more about this here. Previous analysis by GiveWell considered that the effect on all-cause mortality is 3.7x the effect on diarrhea/waterborne diseases alone for children under 5 years old and 2x for adults and children above 5 years old (GiveWell, 2022). We defer to GiveWell on this.

We also defer to GiveWell on the morbidity and development effects, and on the averted medical costs.

- Morbidity: Not all cases of diarrhea would lead to death, but almost all of them lead to suffering and some DALY burden. When averting a case of diarrhea, you may not prevent a death (as that case of diarrhea would not have caused the person to die) but would prevent the suffering causes by having diarrhea. This is what we are trying to capture when discussing the morbidity impacts.

- Development effects: Treating childhood diarrhea likely increased later-life income. GiveWell notes: “We remain very uncertain about this benefit, but include it because other interventions that provide health benefits to children appear to increase adult income. Bleakley 2010 and Cutler et al. 2010 are natural experiment studies that suggest that malaria eradication programs in India, South America, and North America increased the eventual adult income of children that benefited from them. Baird et al. 2016 is a follow-up to a randomized controlled trial that suggests that a deworming program in Kenya increased the eventual adult income of children that benefited from it. Beach et al. 2016 estimates the impact of waterborne disease exposure in early life on adult income in men in the early 20th-century United States. The study estimates that a marked improvement in water quality around the time of birth increased eventual adult income by 1% to 9%, depending on how it is measured.” (GiveWell, 2022)

- Averted medical costs: Parents often seek medical care for children who have diarrhea and the costs of this care are often substantial. By reducing the number of diarrhea cases, we reduce the costs associated with parents taking their children to hospital to be treated.
4 Quality of evidence

4.1 Evidence that a charity can make change in this space

There are many charities involved in this space (see Evidence Review - Existing Charities tab and Section 6.1). Examples include Pure Home Water, Potters without Borders, Good Foundations International, Research Development International Cambodia, Aquaya, MIT's D-Lab, Thirst Aid, and Spouts International. These organizations operate on various scales; for instance, Aquaya is active in 24 countries, Good Foundations International operates in 15 countries, and Pure Home Water has established ceramic filter factories in 52 locations across 31 countries. An example of Pure Home Water's impact can be seen in Ghana, where they have provided sustainable, safe drinking water to over 100,000 people in the impoverished northern region (MIT News, 2013). These organizations illustrate the potential for achieving reasonably large-scale impact. Some of their interventions have been studied, producing empirical evidence of effectiveness.

4.2 Evidence that the change has the expected effects

Effects of ceramic filters and filtration in general in reducing the occurrence of waterborne diseases

The potential for point-of-use water filtration interventions to reduce diarrhea episodes seems well established in the academic literature. We found three systematic reviews that investigated the effects of filtration on the risk of suffering from diarrhea in the general population (Clasen et al., 2015) or in children under five (Darvesh et al., 2017; Wolf et al., 2022). These reviews overlap only in part since they have distinct inclusion criteria and outcomes of interest, but their results ultimately converge to similar numbers.

Effects of ceramic filters in reducing episodes of Diarrhea - All ages

According to a Cochrane review on the subject, the pooled risk ratio for diarrhea episodes in the general population subject to ceramic filtration interventions was 0.39 (95% CI: 0.29-0.53) relative to those in control groups (Clasen et al., 2015).
These results were deemed as based on moderate quality evidence.\(^8\) No serious indirectness, imprecision, or inconsistency was found in these studies, but the overall quality of the evidence was downgraded because “the outcome was measured as self-reported episodes of diarrhea, and is susceptible to bias as most studies were not blinded” (p.5).\(^9\)

However, we see reason to be cautious about the magnitude of this result since it may be contaminated by the lack of masking, publication bias, and other biases. Clason et al. (2015) did not provide funnel plots for filtration interventions, but they found an asymmetry suggestive of publication bias when assessing chlorination studies. We also note that many of the RCTs had short follow-up durations (<1 year), which can be more subject to this sort of bias.\(^10\) Also, the authors of this systematic review “included multiple comparisons for the same multi-armed trials, which double counts the control group participants and yields results in the meta-analysis that are artificially precise” (p.18).\(^11\)

Moreover, these results come mostly from self-reported data on diarrhea episodes, which can be biased due to social desirability bias, Hawthorne effects, bona fide errors, and similar effects. While the authors from Clasen et al. (2015) suggest a correction for these potential biases, they do not provide adjusted odds ratios for each study they reviewed. Therefore, all the values considered from this source are not adjusted for self-reporting biases.

Effects of ceramic filters in reducing episodes of Diarrhea - Under 5s

Another systematic review by Darvesh et al. (2017) looked into the effects of water filters (including ceramic filters) on diarrhea episodes among children under 5 years old, and found a risk ratio of 0.50 (95% CI: 0.37–0.67). The authors did not provide quality assessments at the subgroup level for ceramic filters, but evidence for point-of-use water filters in general (without other water disinfection interventions)

\(^8\) Quality of the evidence was assessed using the GRADE Working Group's grades of evidence. "Moderate quality" evidence is defined as when “further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate" (GRADE Working Group, 2004).

\(^9\) "No serious indirectness: these studies are mainly from low- and middle-income countries, in settings with both improved and unimproved water sources and sanitation." (p.5).

"No serious imprecision: The analysis is adequately powered to detect this effect." (p.5).

"No serious inconsistency: The evidence of benefit is consistent across trials, but there is substantial statistical heterogeneity in the size of the effect." (p.5).

\(^10\) This is an important methodological distinction from the GiveWell (2022) assessment of water quality interventions. In their meta-analysis, they specifically excluded trials with follow-up durations below one year. This would not be feasible for our analysis, since it would exclude all but one study.

\(^11\) This is noticed by the authors, who state that “this bias is unlikely to have significantly impacted the overall quality of evidence or conclusions” (p.18).
was considered of very low quality (8 very low-quality studies, 5 low-quality studies)\textsuperscript{12}. Specific details on the source of biases were not provided.

Wolf et al. (2022) also analyzed point-of-use filtration interventions in general in reducing diarrhea episodes among children under 5 years old, and found a very similar risk ratio: 0.51 (95% CI: 0.41-0.65). Evidence for this subgroup was graded as moderate quality. Statistical testing for publication bias did not find strong evidence of small-study effects (Egger test: \(P = 0.09\)).\textsuperscript{13}

Effects of ceramic filtration devices - with and without Educational component

An open question remains on how much of this effect can be confounded by the additional intervention packages studied in these trials. In particular, we were concerned that the Cochrane review by Clasen et al. (2015) pooled RCTs that included a ceramic filtration intervention \textit{without} a strong educational component and RCTs that included a ceramic filtration intervention \textit{with} a strong educational component.

To estimate the relative effect of education and ceramic filters, we performed our own sub-group analysis of these trials.\textsuperscript{14} We found that ceramic filters \textit{without} an education component had a pooled risk ratio of 0.47 (95% CI: 0.41-0.54) and that ceramic filters \textit{with} an education component had a pooled risk ratio of 0.35 (95% CI: 0.26-0.47). \textbf{This suggests that adding a WASH education component increases the average reduction in diarrhea episodes by an extra 12 percentage points or 22% of the effect size.}

\footnotesize
\textsuperscript{12} Quality of the evidence was assessed using the GRADE Working Group's grades of evidence. “Very low” quality is defined as when “Any estimate of effect is very uncertain” and “Low” quality is defined as when “Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.” (GRADE Working Group, 2004).

\textsuperscript{13} All of these conclusions are presented in a supplement to the main paper that was offline in the main study link when we tried to access it (Oct. 25th, 2023). However, this supplement was still available through ScienceDirect, and we have archived it [here](#).

\textsuperscript{14} We excluded two RCTs. The first RCT was a small (n=74) trial by Abebe et al. (2014), which we excluded because it was performed exclusively among HIV-positive individuals, and yielded an effect size that was considered implausibly high for the general population. Due to the low variance in the results, if included, this study would account for 51% of the weight in the filtration plus education group, and it would lower the risk ratio for this subgroup from 0.29 to 0.24. The second RCT we excluded contained two treatment arms (Lindquist 2014a BOL “CF Only”, and Lindquist 2014b BOL “CF + Edu”), which we excluded because its intervention used a PointONE Filter (a membrane filter) rather than a ceramic filter. We also found a mistake in the meta-analysis (Clasen et al. (2015). Specifically, the RRs and CI for one RCT by Clasen 2004c BOL was inputted wrongly in the Meta-analysis as RR 0.56 CI (0.43, 0.72), while in the RCT by Clasen 2004c BOL, the results indicated an RR of 0.30 (CI 0.20, 0.47). We used the latter RR and CI in our analysis.
We note that we ultimately excluded all but one study in our “Ceramic Filter + WASH education” group\textsuperscript{10,11}. Given that our “Ceramic Filter + WASH Education” group only comprises one study, we refrain from attributing significant weight or credibility to the effectiveness assessment of a charity that combines Ceramic Filters with WASH education.

**Table 1 - Sub-group analysis for ceramic water filter interventions, with and without WASH components.** Source: Our analysis, based on Clasen et al. (2015).

<table>
<thead>
<tr>
<th>Authors</th>
<th>Country</th>
<th>Sample size</th>
<th>Risk ratio (95% CI)</th>
<th>Weight*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ceramic filters only</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clasen et al (2004c)</td>
<td>Bolivia</td>
<td>280</td>
<td>0.3 (0.2-0.47)</td>
<td>10%</td>
</tr>
<tr>
<td>Brown et al (2008a)</td>
<td>Cambodia</td>
<td>598</td>
<td>0.51 (0.41-0.63)</td>
<td>40%</td>
</tr>
<tr>
<td>Brown (2008b)</td>
<td>Cambodia</td>
<td>598</td>
<td>0.58 (0.42-0.72)</td>
<td>26%</td>
</tr>
<tr>
<td>Clasen (2005)</td>
<td>Colombia</td>
<td>680</td>
<td>0.45 (0.29-0.68)</td>
<td>10%</td>
</tr>
<tr>
<td>Clasen (2004b)</td>
<td>Bolivia</td>
<td>317</td>
<td>0.51 (0.28-0.92)</td>
<td>5%</td>
</tr>
<tr>
<td>du Preez (2008)</td>
<td>South Africa</td>
<td>115</td>
<td>0.21 (0.12-0.37)</td>
<td>6%</td>
</tr>
<tr>
<td>URL (1995a)</td>
<td>Guatemala</td>
<td>423</td>
<td>0.47 (0.20-1.13)</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Ceramic filters only (pooled)</strong></td>
<td><strong>3,011</strong></td>
<td><strong>0.47 (0.41-0.54)</strong></td>
<td><strong>100%</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Ceramic filters plus WASH education</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>URL (1995b)</td>
<td>Guatemala</td>
<td>432</td>
<td>0.35 (0.29-0.53)</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Ceramic filters plus education (pooled)</strong></td>
<td><strong>432</strong></td>
<td><strong>0.35 (0.29-0.53)</strong></td>
<td><strong>100%</strong></td>
<td></td>
</tr>
</tbody>
</table>

* Based on the inverse variance weight method, rescaled to 0-100%.

**Effects on all-cause mortality**

There is an open discussion in the relevant literature on whether water quality interventions can lead to all-cause mortality reductions even to a greater proportion than the mortality caused by waterborne diseases alone - the so-called “Mills-Reinke” phenomenon. Some experimental evidence supports this hypothesis:
when reviewing the effect of water quality interventions on all-cause mortality of children under 5 years old, Kremer et al. (2022) (working paper) found a mortality reduction of 28% (95% CI: 8%-45%) or 30% (95% CI: 8%-51%) depending on the pooling method, which can not be explained by the reductions in waterborne diseases alone.\textsuperscript{15} This is also consistent with quasi-experimental analyses like Clutter & Miller (2005), as well as with observational studies about historical water quality improvements in the United States, Europe and Japan.\textsuperscript{16}

This issue was investigated in some depth in the GiveWell (2022) Water Quality Interventions report. This ultimately concluded that the Mills-Reincke phenomenon was probably true for under-5 mortality, and to a lesser extent to over-5 mortality, but was uncertain about the magnitude of the phenomenon. Due to time constraints, we have not reassessed GiveWell’s conclusion on this topic. In our own calculations, we defer to their estimates of a +270% Mills-Reincke effect for under-5s (relative to the effect on waterborne diseases) and +135% for over-5s.

Effects on morbidity and other indirect measures

Considering the mechanisms through which this intervention functions, we find it plausible that it would have positive effects also through reductions in morbidity as well as associated burdens, such as medical costs averted and development effects to affected children.

For morbidity, IHME (2019) data suggest that 5.8% of the DALYs lost per year due to unsafe water sources in countries with low socio-demographic index across all ages derive from disability rather than death. Since most data we considered rely on proxy outcomes (diarrhea episodes) instead of direct measures of mortality and morbidity, we tentatively assume the risk ratios for the intervention apply equally to both of them and consider them to DALYs indistinctly of years lost to disability (YLDs) and years of life lost (YLLs).\textsuperscript{17}

\textsuperscript{15} On their review of this paper, GiveWell (2022) compared these results with data from the Global Burden of Disease study, and concluded that chlorination should account for only a 3.3% reduction in all-cause mortality of children under 5 years old, which is only about one-eighth of the Kremer et al. 2022 estimate and about one-quarter of their own estimate.

\textsuperscript{16} See GiveWell (2022) “Studies of historical water quality improvements” section for a short review of this line of evidence.

\textsuperscript{17} Note that this is not necessarily true. For example, filtration and other water treatments could remove some but not all pathogens, which would still lead to less intense diarrhea episodes (less effect on YLDs) but prevent mortality from more severe episodes (more effect on YLLs). However, since mortality clearly dominates the analysis here, it is unlikely that this would make much difference for our analysis.
As for medical costs and development effects, we defer to GiveWell (2022) estimates for chlorination interventions. In their cost-effectiveness analysis of In-Line Chlorination in Kenya, they attribute 24% of the value of the intervention to medical costs averted and 29% to development effects (increases to the future income of children in the long run). For Dispensers for Safe Water, these proportions vary from 22% (Uganda) to 33% (Kenya) for medical costs averted; and from 17% (Uganda and Malawi) to 20% (Kenya) for development effects.

4.3 Evidence on other key uncertainties

Relative incidence of protozoa, bacteria and virus-related enteric diseases

Each water treatment method and device has different efficacies in removing various pathogens types. For example, chlorination methods tend to perform badly in removing pathogens that are larger in size. Inversely, filtration methods tend to perform much better in removing these relatively larger pathogens, like protozoa and bacteria, but they cannot be trusted to remove smaller particles, like viruses (Unicef, 2020, pp. 4-8). In the latest independent evaluation of Household Water Treatments by the World Health Organization, the three ceramic filtration devices evaluated attained the targeted protection of at least 2 log (99%) removal of bacteria and protozoa, but they were not evaluated against viruses (WHO, 2019a, p. 48).

In a laboratory virus challenge test by Lantagne (2001), after six hours, a ceramic filter failed to achieve more than a 0.09 log (18.7%) reduction in concentration. As the author explains:

“Viruses, on the other hand, are quite small, because they do not contain their own replication material. Due to their small size (0.02-0.2 microns), it was expected that the pore size of the PFP filter would not be small enough to trap viruses. The removal rate of viruses then depends on inactivation due to

---

18 “For practical purposes, cysts and eggs of protozoa and helminths [parasitic worms] may be considered resistant to disinfection with chlorine. They are killed at high doses or after prolonged contact times, but these are often impractical. Cysts and eggs of protozoa and helminths should be removed by filtration prior to disinfection or, in the case of groundwaters (springs and wells), excluded by source protection.” (World Health Organization, “Fact Sheet 2.17: Inactivation of microbes by chlorine”, pg. 117)

19 Water treatment technologies are evaluated in *logs* of pathogen removal: 1 log means a 90% removal; 2 log means 99% removal; 3 log means a 99,9% removal and so on.
interaction with the colloidal silver, or other effects such as electrostatic attraction to the ceramic.” (page 69).

This might be relevant for a new charity, because the numerous diarrhea-causing pathogens are associated with distinct disease burdens in the populations where they are more prevalent. For example, the Global Enteric Multicenter Study (GEMS) study in Africa and Asia showed that enterotoxigenic E. coli and enteropathogenic E. coli – both bacteria – were the pathogens that were associated with the highest increases in risk of death for infants between 0 and 11 months old. Whereas, among toddlers aged 12–23 months, Cryptosporidium – a protozoa – was associated with the highest increases in risk of death (Kotloff et al., 2013).

Therefore, relative etiology (which specific pathogens cause a condition) of waterborne diseases in each location can be a major factor to assess the generalizability of the evidence for water treatment methods and the best places to start a new charity. Fortunately, the Global Burden of Disease provides mortality and morbidity data categorized by etiology, including some common pathogens responsible for diarrhea episodes (IHME, 2019, “Etiology” GBD Estimate). According to their estimates, in 2019, bacteria caused 52% of the burden for diarrheal diseases in countries with low socio-demographic index; while 16% of the burden was caused by protozoa and 32% by viruses. However, this number varies across countries.

Contamination by other, non-biological pollutants

We have not assessed the effect of ceramic water filters specifically for non-biological pollutants, like arsenic, pesticides and other neurotoxicants. These can be relevant sources of suffering, cognitive deficits in exposed populations, and premature deaths. Given time constraints, we did not prioritize this as a line of research. However, our prior is that ceramic water filters will fail to catch these contaminants as they have molecule-sized particles which are much smaller than viruses.

During a broader review of the literature, we came across at least one laboratory study, by Van Halem (2006), suggesting that ceramic water filters can make certain toxic metals - especially arsenic - concentrations higher in filtered water than in the source water, depending on the clay used for its manufacturing. This should be a

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20 For a quick review of some of these problems, see the WHO (2022) fact-sheet on arsenic, and the cause exploration piece on organophosphate pesticides and other neurotoxicants by Stewart (2022).
consideration when deciding where to work as a new organization. You could try to avoid areas where arsenic is known to be present, or if you go ahead and manufacture ceramic filters in these regions, the selected clay for the filter material should be tested for the leaching of arsenic.

Other water quality devices and techniques

Besides filtration and chlorination, a few other water treatment techniques and devices are available for usage in low income countries and emergency scenarios. **Unicef (2020)** has published a comprehensive review of the pros and cons of many of these alternatives, mostly focusing on filtration. This evaluation is summarized in below Table 2. These include: ceramic filters (bucket + pot, bucket + candle, ceramic siphon), membrane filters (gravity-based, pumping-based, screw-cap filters), multi-step filters, biosand filters, and solar-based disinfection (plastic bottles and solar bags).

After qualitatively reviewing arguments in this report, we stood to our initial impression that ceramic filters (bucket + pot, or bucket + candle) were among the most promising devices to be distributed in a development context. In general, these are low cost (0.001 USD/L - 0.0025 USD/L\(^2\))\(^{21}\), are easy to set up and maintain, have a decent lifetime (~2 years), and do not present big acceptability challenges. Other filters, like ceramic siphons and gravity membrane filters, tend to have more complicated set up and/or maintainability (e.g., requiring consumables or regular backwashing), which we considered would demand greater supervision and costs. Some filters (screw-cap, pumping filters) seem more adequate to emergency response settings, and others (biosand, multi-step filters) have variable or lower efficiencies in removing pathogens from the water.\(^{22}\)

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\(^{21}\) Respectively for the Purifaaya silver coated ceramic pot plus bucket filter, and the Katadyn Rapidyn horizontal ceramic candle. **This is not** the cost of the intervention, but rather the cost of procurement of the device alone. See **Unicef (2020)**, pp. 6-8, for more information on the filters.

\(^{22}\) A remark should be made about solar disinfection methods, which we believe have the potential to be cost-effective in some settings. Clasen et al. (2015) meta-analysis has suggested that these methods can be more effective in preventing diarrhea episodes than chlorination, for example (RR 0.62, 95% CI 0.42-0.94, versus a RR 0.77 for chlorination, 95%CI 0.65-0.91), even though this difference is not statistically significant (P = 0.165).
Table 2 - Comparison of different methods looking at key parameters. Source: [Unicef (2020)](https://www.unicef.org).

<table>
<thead>
<tr>
<th>Type of filter/treatment</th>
<th>Context</th>
<th>Transportability</th>
<th>Price</th>
<th>Protection</th>
<th>Flow rate</th>
<th>Capacity/Lifetime</th>
<th>Set up</th>
<th>O&amp;M</th>
<th>Safe storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bucket + ceramic pot</td>
<td>Development</td>
<td>😞</td>
<td>😊</td>
<td>😞</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
</tr>
<tr>
<td>Bucket + ceramic candle(s)</td>
<td>Development</td>
<td>😞</td>
<td>😊</td>
<td>😞</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
</tr>
<tr>
<td>Ceramic siphon filter</td>
<td>Development</td>
<td>😞</td>
<td>😊</td>
<td>😞</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
</tr>
<tr>
<td>Gravity membrane filters</td>
<td>Development</td>
<td>😞</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
</tr>
<tr>
<td>Pumping membrane filters</td>
<td>Both</td>
<td>😞</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
</tr>
<tr>
<td>Screw-cap membrane filters</td>
<td>Emergency</td>
<td>😊</td>
<td>😞</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
</tr>
<tr>
<td>Multi-step filtration</td>
<td>Development</td>
<td>😞</td>
<td>😊</td>
<td>😞</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
</tr>
<tr>
<td>Biosand filters</td>
<td>Development</td>
<td>😞</td>
<td>😊</td>
<td>😞</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
</tr>
<tr>
<td>PET plastic bottles (SODIS)</td>
<td>Development</td>
<td>😊</td>
<td>😊</td>
<td>😞</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
</tr>
<tr>
<td>Solar bags</td>
<td>Emergency</td>
<td>😍</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
</tr>
</tbody>
</table>

*Without suction, the flow rate is low.
5 Expert views

In seeking the views of experts, we strove for insights into the cost and logistics of this program. We believe that individuals with on-the-ground experience will be instrumental in our cost and theory of change analysis.

In total, we contacted ten entities actively engaged in this area. However, only two expert interviews could be conducted prior to the completion of this report. These interviews were with Yvette Neh and Michael Anyekase, both from Pure Home Water, a non-profit organization based in Tamale, Ghana. Established in 2005 by Susan Murcott, an MIT lecturer, Pure Home Water specializes in producing and distributing ceramic filters to improve water quality and address sanitation and hygiene challenges in northern Ghana. They are also involved in training, water quality testing, and filter distribution.

These interviews have been useful in validating our approach, refining cost estimations, and considering additional factors that may impact the practicality and sustainability of ceramic water filters in low-income regions.

Key insights from these interviews include:

1) **Validation of our Theory of Change**: Pure Home Water's approach is in line with our theory of change. Their focus on producing, distributing, and providing basic training for ceramic filters corroborates our model.

2) **Extended lifespan of filter**: Unless they are used in high water turbidity settings, their ceramic filters are expected to be effective for 4-6 years, surpassing our initial 2-year estimate.

3) **Increased confidence in and refinement of cost estimates for ceramic filters**: Prior to these discussions, we estimated the cost of ceramic filters at approximately $15 USD. Pure Home Water's detailed breakdown (ceramic clay filter: $6.67, bucket: $6.67, spout: $4.17, additional components: $1.67) totals to around $19 USD. This refined estimate increases our confidence in our initial cost estimate, while it aids in fine-tuning our CEA.

4) **Increased confidence in our cost estimate for distribution**: Pure Home Water indicated that distributing 1,000 filters costs $3,000 USD, equating to $3 per filter set. This challenges our earlier estimate, which pegged distribution costs at 50-100% of the filter's cost. Despite this new information, we have opted for a conservative estimate, maintaining distribution costs at 50% of the filter price.
5) **Consideration of additional components**: Pure Home Water includes a metal stand with their filters that they reported significantly reduced breakage risks. This is an aspect we are contemplating adding to our ceramic filter sets. This would increase the cost of the filters in order to extend their lifespan. More careful consideration is needed.

**Other important questions we would like to ask, but were unable to prior to the completion of this report, are:**

a) How much can Pure Home Water scale up their operations?

b) What is Pure Home Water's maximum monthly/quarterly/yearly filter distribution capacity to communities?

Answering these questions will provide valuable insights to prospective charity founders about the logistics and scalability of operating a ceramic filter factory.
6 Geographic assessment

The geographic assessment was done in two stages. First, we looked at where existing organizations are working or have worked. This information was used as input in the formal geographic assessment to measure how much attention an issue is being paid. Second, we conducted a formal geographic assessment to find the top priority countries for starting a new nonprofit.

6.1 Where existing organizations work

We conducted desk research to understand organizations that work in this space. Overall there seems to be space for a new organization as we could not find ongoing efforts in many of the most promising countries from the geographic assessment.

It seems like most existing NGOs do not make the water filters themselves but assist and train others in setting up production facilities and factories that make the water filters locally, similar to the theory of change we propose for a new organization in the space. Many organizations appear to have a small budget. We also found many local organizations and factories making these ceramic water filters. Many of these factories seem to be fairly small and local, making in the order of 10,000 filters. We could find existing efforts across ~40 countries, many of which were not in the top 50 countries in the geographic assessment.23

Table 3 - Organizations working in the space

<table>
<thead>
<tr>
<th>Organization</th>
<th>What it does</th>
<th>Where it works</th>
<th>What this means for our geographic assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good Foundations International</td>
<td>Assists in the production of colloidal silver-enhanced ceramic water purifiers. They do not manufacture these filters themselves, but they assist and train others to do so and in setting up production.</td>
<td>Guatemala, Honduras, Mexico, Cambodia, Bangladesh, Ghana, El Salvador, Sudan, Kenya, Benin, Yemen, Nigeria, Tanzania, Peru, Somaliland, Nicaragua, and 14 other countries.</td>
<td>A fairly small charity despite the number of countries listed, with an annual revenue below $100,000.</td>
</tr>
</tbody>
</table>

23 There were only 6 countries excluded due to existing work that were in the top 50, 3 of which were in the top 20 and 1 (Nigeria) in the top 5. You can see this here.
facilities.

<table>
<thead>
<tr>
<th><strong>Potters Without Borders</strong></th>
<th>Assists in the production of ceramic water filters. They do not manufacture these themselves, but they provide technical assistance to organizations seeking to establish and maintain filter factories.</th>
<th>Indonesia, Ghana, Nicaragua, Guatemala, Laos, and Papua New Guinea.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pure Home Water</strong></td>
<td>Manufacture “AfriClay Filter” ceramic pot water filters. Also provides training in the proper use of these filters. This is one of the factories that Potters Without Borders supports.</td>
<td>(Northern) Ghana</td>
</tr>
<tr>
<td><strong>Resource Development International Cambodia</strong></td>
<td>Manufactures and distributes ceramic water filters.</td>
<td>Cambodia</td>
</tr>
<tr>
<td><strong>Abundant Water</strong></td>
<td>Producing and distributing ceramic water filters.</td>
<td>Laos</td>
</tr>
<tr>
<td><strong>PATH</strong></td>
<td>It seems like PATH ran a pilot to generate demand for water filters, including ceramic water filters. This work doesn’t seem to have moved past this pilot.</td>
<td>Cambodia and Kenya PATH is no longer working on this, so this is mostly irrelevant.</td>
</tr>
<tr>
<td><strong>Ceramic Water Filter Solutions</strong></td>
<td>Provides education and training on how to make ceramic water filters.</td>
<td>Mexico, Nepal, and Nigeria</td>
</tr>
<tr>
<td><strong>Thirst Aid</strong></td>
<td>Produces and sells ceramic water filters.</td>
<td>Myanmar</td>
</tr>
<tr>
<td><strong>SPOUTS International</strong></td>
<td>Creating and selling 10,000 filters per month</td>
<td>Uganda and Rwanda</td>
</tr>
<tr>
<td>Organization</td>
<td>Description</td>
<td>Location</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td>Friends Peace Teams</td>
<td>A commenter on the EA forum mentioned that they are producing ceramic water filters using local materials and also training others on how to make these filters with these materials. This information could not be found on their website.</td>
<td>Indonesia and the Philippines</td>
</tr>
<tr>
<td>Barka Foundation</td>
<td>Supporting a local ceramic company to produce, sell, and distribute ceramic water filters. It seems like they purchase these filters at a profit for this local company and then distribute them at a subsidized cost to poor rural villagers.</td>
<td>Burkina Faso</td>
</tr>
<tr>
<td>Unicef</td>
<td>Involved in a public-private partnership with the government to produce and distribute ceramic filters.</td>
<td>Vietnam</td>
</tr>
<tr>
<td>Wine to Water</td>
<td>Produces and sells ceramic water filters.</td>
<td>Dominican Republic, Tanzania, and Haiti.</td>
</tr>
<tr>
<td>Baptist Global Response</td>
<td>Distributes ceramic water filters to those who need it.</td>
<td>Unclear.</td>
</tr>
</tbody>
</table>
## 6.2 Geographic assessment

In order to assess where a hypothetical Ceramic Filtration Charity would have the most impact per dollar spent, we developed a Geographical Weighted Factor Model (GWFM), available in a supplementary spreadsheet\(^{24}\). This model took into account 4 variables: the rate of DALYs associated with the risk of contracting a diarrheal disease due to consumption from unsafe water sources (adjusted for the percentage of such DALYs that are associated with bacteria or protozoa) (50% weight); the Purchase Power Parity conversion factors from the World Bank (25% weight); the average household size in each country (10% weight); and the Fragile State Index (15% weight).

<table>
<thead>
<tr>
<th>Organization</th>
<th>Description</th>
<th>Location</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>International Development Enterprises</strong></td>
<td>Produces and sells ceramic water filters.</td>
<td>Cambodia</td>
<td></td>
</tr>
<tr>
<td><strong>TivaWater</strong></td>
<td>Providing water filters to communities in need. It seems like they distribute them through churches.</td>
<td>Uganda and Guatemala</td>
<td></td>
</tr>
<tr>
<td><strong>University of Pittsburgh’s ceramic water filters project</strong></td>
<td>Provides technical support to NGOs and community organizations that develop and implement low-cost ceramic water filters.</td>
<td>Unclear.</td>
<td>This work doesn’t seem super relevant as it is one level removed as it helps NGOs to implement rather than helping people build factories, for example.</td>
</tr>
</tbody>
</table>

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\(^{24}\) We also provide a video walkthrough of this spreadsheet, designed to make it easier for people to understand its structure when seeing it for the first time.
Scale of the problem

Rate of DALYs associated with the risk of contracting a diarrheal disease due to consumption from unsafe water sources

The basis for our estimate for the scale of the problem was the disease burden rate, measured in disability-adjusted life years calculated to be lost per 100,000 people due to risks associated with consumption of water from unsafe sources. This estimate is provided by the Global Burden of Disease (GBD) 2019 study (IHME, 2019).

Adjustment for the prevalence of various pathogen types

Considering the protection profile provided by ceramic filters, we do not expect all the burden caused by diarrheal diseases linked to unsafe water consumption to be preventable by this intervention (see Section 4.3). Ceramic filters are not effective at removing viruses from the water.

Therefore, we used GBD 2019 data on disease etiology to determine the relative burden caused by bacteria, protozoa and viruses in each country (IHME, 2019). We then multiplied the summed percentage of the burden caused by bacteria and protozoa by the burden obtained in the previous step. This was considered the scale of the problem effectively attainable by the intervention.

Tractability and costs

Purchase Power Parity conversion factor

Purchase Power Parity (PPP) is a standard methodology used to compare living standards across various countries. Conversion factors from market exchange rates are provided by the World Bank's International Comparison Program (World Bank, 2023).

Since the conversion factors provide a measure of the differences in price levels between countries, we use them as proxies for the differential costs of operating in any given country for which there are results available. This is intended as a more

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25 We have also considered using the same metric in absolute terms. We ultimately decided to prioritize the population-relative metric because it is not clear that this intervention's costs would be dominated by fixed, rather than variable costs. Since we expect most of the costs to come from the distribution logistics, it makes more sense to prioritize countries for how easy it is to find someone there who needs the intervention (relative metric).
manageable replacement for separately considering each cost necessary to implement the Theory of Change.

Household size

Household sizes are likely a major factor for determining the cost per person treated. We expect most interventions to give away one - and only one\textsuperscript{26} - filter per household. Consequently, we expect sites where more people share the same household to have a lower cost per person treated.

We obtained average household sizes data from the Global Data Lab (n.d.) (GDL), which aggregates data from several sources.\textsuperscript{27} We considered the latest year for which there was survey data as the best guess of the real, current average household sizes for each country.

Fragile State Index

In order to assess the difficulty of starting a new charity in a given country, we used the 2023 Fragile State Index (FSI) as an indicator (The Fund for Peace, 2023). To exclude countries in active civil war or in a state of total collapse of the civil society, we also imposed an arbitrary cutoff of 1.00 in this factor's Z-scores, so that any country above this level should not be recommended as a priority place to set up a new charity.

6.3 Results

The combined geographic weighted factor model can be found in this supplementary spreadsheet (tab “GWFM ~ Results”). The ten most promising countries identified were, in descending order, Chad, Central African Republic, South Sudan, Niger, Nigeria, Somalia, Burundi, Cameroon, Eritrea and Mali. However, we exclude Chad, Central African Republic, South Sudan, and Somalia from our recommendations due to

\textsuperscript{26} Note that, if household sizes are really large, the filter’s flow rate might become a limiting factor for full adoption. According to Unicef (2020, p. 7), a bucket + pot ceramic filter yields around 3.5L/h of clean water per hour. If each person needs 5L of water per day (UNDP, 2006, p. 5), with a consumption spread uniformly throughout 16 hours of the day, the maximum household size supported per filter would be around 11.2 people ($3.5L.h^{-1} \times 16h / 5L\text{person}^{-1}$). This theoretical calculation has been separately validated by interviews with experts from Pure Home Water experts, who report distributing more than one filter per household only when they have more than ten people.

\textsuperscript{27} Demographic and Health Surveys (DHS), the UNICEF Multiple Indicator Cluster Surveys (MICS), the Integrated Public Use Microdata Series (IPUMS) International, Afrobarometer Surveys, Americas Barometers (LAPOP Surveys), Arab Barometer Surveys, and other country-specific sources (see a full list of their sources here)
our cutoff on the Fragile State Index, which suggests these are very unstable countries to work in. We also extend this logic to exclude Niger because we believe its situation has deteriorated further than its latest (2023) FSI score portrays.

**Therefore, our final recommendation is that Nigeria, Burundi, Cameroon, Eritrea, and Mali are top priority countries to be further investigated and potentially receive this intervention in a cost-effective manner.**

### 6.4 Other considerations on country choice

We wanted to highlight the importance of tailoring water purification methods to specific regions and household characteristics for the most effective and efficient impact when choosing a target country for a new charity.

We believe there are certain locations where it is most appropriate to use chlorination methods, and others where ceramic filters are most appropriate. Choosing between chlorination and ceramic filters probably depends mostly on two factors:

1) **The relative incidence of disease due to bacteria, protozoa, and viruses:** Areas with higher prevalence of protozoa and bacteria are more likely to benefit more from ceramic filters, while those with much higher prevalence of bacteria and viruses may benefit more from chlorination methods. This is because ceramic filters are better at filtering bacteria and protozoa, while chlorination methods are better at killing viruses and bacteria. See Section 4.3.

2) **Average household sizes:** in regions with larger household sizes (>4-5 members), ceramic filters are expected to be more cost-effective. This is because providing one ceramic filter per household results in a greater impact in larger households. For example, if we provide a ceramic filter to Household A with 6 members and Household B with 3 members, the cost is expected to be only somewhat increased (due to a possibly reduced lifespan and increased need to replace the filter) but the impact is expected to be twice as significant in Household A. In contrast, chlorination interventions, like dispensers for safe water (DSW), operate at a community level and are less influenced by household size.
7 Cost-effectiveness analysis

We have modeled the cost-effectiveness of this intervention for Nigeria, Kenya, Malawi, and Uganda. Nigeria was chosen as this is the top tractable option in our geographic assessment. Kenya, Malawi, and Uganda were chosen so that we can directly compare the provision of free ceramic filters at the household level to Evidence Action's community-level chlorination interventions (in-line chlorination and chlorine dispensers). This model evaluates the costs and benefits over a two-year period as this is the expected lifespan of a ceramic filter.

Note: As this model was created during the research training program, it looks different from our other CEAs. As we are time-constrained, we haven’t created a new model but instead have applied various adjustments to the original model to bring it more in line with our other CEAs. We will explain this in more detail where relevant below.

7.1 Costs

We modeled the intervention as having two types of costs:

- **Fixed costs**: This would include co-founder salaries and any additional staff that provides operations management, program management, fundraising, finance, and HR. It would also cover costs like flights, software, and conference fees. Fixed costs were not included in the original CEA so we have added an adjustment to account for these fixed costs.

- **Variable costs**: This is the cost of manufacturing and providing ceramic filters per person treated per year taking into account the following four factors:
  - Average cost of filters: We used 4 different sources to find the average cost of a filter. We made an assumption that since this is the market price, this also incorporated the cost of manufacturing. The average cost was estimated at $17.62 per ceramic filter.
  - Average household size: Since each filter is intended to treat an entire household, we needed to understand the average household size in each country. We ultimately used data from Global Data Lab, which aggregates data from various regional and country-level demographic and health surveys.
Delivery cost: To estimate the delivery cost of the service, we tentatively considered that it would be 50% of the cost of the filter.

Education Costs: In the ceramic filter + education intervention, there was an educational component that included training and educating community promoters. The average training cost per household treated was determined to be $12.70.

7.2 Effects

For the effectiveness side of our analysis, we borrowed as much as possible from the methodology proposed by GiveWell’s (2022) cost-effectiveness analysis of Evidence Action’s in-line chlorination and Dispensers for Safe Water programs. This means we broadly considered four paths to impact, which were ultimately converted to DALY-equivalent units and GiveWell moral weight units:

- Reductions in all-cause mortality and morbidity of children under 5 years old.
- Reductions in all-cause mortality and morbidity of children and adults over 5 years old.
- “Developmental effects” from long-term income gains related to less morbidity among children under 14 years old.
- Aversion of medical costs that would be incurred by families or the government with inpatient and outpatient care for diarrhea episodes among children under 5 years old.

Diarrheal mortality and morbidity

Data for mortality and morbidity was extracted from IHME’s (2019) Global Burden of Disease (GBD) study. We considered the number of DALYs, YLLs, YLDs and deaths related to diarrheal diseases caused by enteric infections: 1) eight bacteria (Aeromonas, Campylobacter, Cholera, Clostridium difficile, enteropathic E. Coli, enterotoxigenic E. Coli, non-typhoidal Salmonella, and Shigella), 2) two protozoa (Cryptosporidium and Entamoeba) and 3) two viruses (Norovirus and Rotavirus) for which GBD 2019 provided detailed data. Supplementary data for population per age

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28 Each GiveWell moral weight unit equals the doubling in consumption for one person during a year. A disability-adjusted life year averted equals 2.3 moral units. See GiveWell (2020) for a full discussion (especially section “What are the results?” for the final weights).
group, incidence rates in under 5s and disease burden rates in children under 5 and 5 to 14 years old were also obtained from GBD 2019.

Impact through mortality and morbidity was calculated by multiplying the total DALYs lost per year due to those diarrheal diseases by 1 minus the adjusted risk ratios for ceramic filters (without education) found in our subgroup analysis of Clasen et al. (2015). This makes the assumption that the same risk ratios observed for the reduction in diarrhea episodes would also extrapolate unchanged to morbidity and mortality. We believe that this assumption may not hold – not all diarrhea episodes result in death, and it is unclear whether reducing the number of episodes would linearly reduce morbidity or mortality.

This assumption was made as the studies evaluating ceramic filter use consider diarrhea episodes as the primary outcome, not mortality. Although some studies do report on mortality, this was not the primary outcome and many of the studies are underpowered to investigate these effects. This meant that we couldn’t just use the results of a study to model mortality and morbidity reductions in our CEA, we had to do some kind of calculation.

We therefore adjust the CEA here to account for this uncertainty. Our alternative model instead uses the case fatality ratio of diarrhea in the modeled country to calculate mortality rates. This was done as follows:

1. Find the current diarrhea incidence and number of deaths due to diarrhea in the population using incidence data from GBD. This will give us diarrhea incidence and number of deaths due to diarrhea before the intervention.
2. Calculate the case fatality ratio (CFR) of diarrhea. This can be calculated as follows: diarrhea deaths/incidence of diarrhea.
   a. We assume that the case fatality ratio will stay the same before and after intervention. That is, this intervention does not reduce the mortality rate due to diarrhea, it just decreases the incidence of diarrhea.
3. Calculate the reduced diarrhea incidence in the population after intervention using the risk ratio for decreased diarrheal episodes from the literature\(^29\). This will give us diarrhea incidence after the intervention.
4. Calculate the number of deaths due to diarrhea after intervention by multiplying the diarrhea incidence after the intervention by the case fatality ratio calculated

\(^{29}\) Note that we did apply internal and external validity adjustments to this risk ratio.
earlier. This will give us the number of deaths due to diarrhea after the intervention.

5. Calculate the deaths averted due to this intervention as follows: Deaths before intervention - deaths after intervention.

We then also calculated the number of DALYs averted due to this intervention by multiplying the deaths averted by 36.53 which is GiveWell's DALY weighting for an under-5 death averted.

Due to time constraints, we only did this updated analysis to under-5 mortality and not any of the other impacts that are being modeled (over-5 mortality, morbidity effects, developmental effects, and averted medical costs).

Internal and external validity adjustments

We then applied internal and external validity adjustments borrowed from GiveWell (2022). We also added an external validity adjustment based on the relative incidences of various diarrhea-causing pathogens. This adjustment assumes that ceramic water filters prevent bacteria and protozoa-caused diarrhea episodes, but does not provide any protection against viruses. This is in line with the physical functioning of this treatment method, as well as laboratory evaluations, as previously discussed in the Section 4.3.

Drawing on this assumption, we postulated that the magnitude of the effect of ceramic water filters in various locations would be directly proportional to the proportion of diarrhea burden caused by bacteria and protozoa pathogens, relative to the total diarrhea burden (including viruses). Since point-of-use water treatment studies do not typically report which pathogens caused the observed diarrhea cases, we relied on country-level data from the GBD study to approximate relative burdens per pathogen group in the study sites.

Table 4 - Per country adjustments to risk ratios based on the relative burden of diarrhea caused by bacteria and protozoa, versus all diarrhea cases. Source: IHME (2019) and subgroup analysis of Clasen et al. (2015). See supplementary spreadsheet for full calculations.
We used this to adjust the expected effect of ceramic water filters in various countries. For example, if a country has 2x the proportion of the burden of diarrhea diseases preventable by ceramic filters - i.e., caused by bacteria or protozoa - as the (weighted) average of the countries considered in our subgroup analysis of ceramic water filters, we expect the effect of the intervention in this country to be 2x bigger than observed in the (pooled) results of the studies. Conversely, if less - say, 0.5x - cases are caused by bacteria and protozoa, the effect would be smaller by the same proportion - 0.5x the effect.

Besides these adjustments, we also applied a linear downward adjustment of -10% of the effect for all countries in the context of a charity implementing this intervention, to

<table>
<thead>
<tr>
<th>Country</th>
<th>Study</th>
<th>% of diarrhea burden caused by bacteria and protozoa</th>
<th>Observed risk ratio for filtration</th>
<th>Estimated risk ratio if diarrhea burden was equal to the average of Low SDI countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolivia</td>
<td>Clasen et al. (2004b)</td>
<td>34%</td>
<td>0.51</td>
<td>0.01*</td>
</tr>
<tr>
<td>Bolivia</td>
<td>Clasen et al. (2004c)</td>
<td></td>
<td>0.56</td>
<td>0.11</td>
</tr>
<tr>
<td>Bolivia</td>
<td>Lindquist (2014a)</td>
<td></td>
<td>0.21</td>
<td>0.01*</td>
</tr>
<tr>
<td>Cambodia</td>
<td>Brown et al. (2008a)</td>
<td>41%</td>
<td>0.51</td>
<td>0.18</td>
</tr>
<tr>
<td>Cambodia</td>
<td>Brown et al. (2008b)</td>
<td></td>
<td>0.58</td>
<td>0.30</td>
</tr>
<tr>
<td>Colombia</td>
<td>Clasen et al. (2005)</td>
<td>48%</td>
<td>0.45</td>
<td>0.22</td>
</tr>
<tr>
<td>Guatemala</td>
<td>URL (1995a)</td>
<td>48%</td>
<td>0.47</td>
<td>0.24</td>
</tr>
<tr>
<td>South Africa</td>
<td>Du Preez et al. (2008)</td>
<td>71%</td>
<td>0.21</td>
<td>0.18</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>Du Preez et al. (2008)</td>
<td>66%</td>
<td></td>
<td>0.24</td>
</tr>
<tr>
<td><strong>Pooled results</strong></td>
<td></td>
<td></td>
<td>0.45</td>
<td>0.11</td>
</tr>
</tbody>
</table>

* For the direct proportionality with the “% of diarrhea burden caused by bacteria and protozoa” variable to hold, these risk ratios would need to be negative, which is not realistic. In cases like this, we capped the risk ratios at 0.01.
account for the fact that we expect this sort of implementation to be less intensive than what researchers did in RCTs. This is the same adjustment used by GiveWell (2022).

**All-cause mortality and morbidity**

The overall impact on mortality and morbidity calculated as above was multiplied by GiveWell's estimates of the Mills-Reincke effect (3.7x for under 5s and 2.35x for over 5s) to estimate the effects on all-cause mortality and morbidity.

**Developmental effects**

Developmental effects were obtained by applying GiveWell's development effects modeling approach, which estimates the adult consumption benefits of early-life health interventions in cases where there is no compelling direct evidence. This model suggests that developmental effects for chlorination are 44% of the amount estimated for seasonal malaria chemoprevention, which in turn are valued at 0.126 moral weight units or 0.055 DALY-equivalent units (see GiveWell's accessory document and calculations).

**Aversion of medical costs**

Aversion of medical costs were calculated by using the total expenditure on inpatient and outpatient treatment of diarrhea episodes in children under 5 per World Bank income group calculated by Baral et al. (2020). We adopted the proportion of diarrhea cases in Kenya that receive inpatient care, which is approximately 5.8%. Meanwhile, the proportion for outpatient care was estimated based on the geometric mean of data from Kenya, Malawi, and Uganda, amounting to 58.6%. This method follows the guidelines set forth by GiveWell (2022).

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30 This source does not provide data for high income countries, so we assumed that their costs would be the same as the costs for upper middle income countries. This was done solely for completeness, since we do not expect high income countries to be prioritized for this intervention.
Adjustment for time discounting

The original model doesn’t fully include time discounting. Our other CEAs assume that there is some time taken in order to scale and possible delays in health effects. We adjust the original CEA to account for this effect assuming that the charity takes 3.5 years to reach scale and that future health benefits are discounted by 1.4%. There is no delay in health effects in this case.

7.3 Results

**Under our model parameters and choices, this intervention has an average estimated cost-effectiveness of $77 per DALY** (ranging from $15-$118 depending on the country modeled). Table 5 below presents the cost-effectiveness estimates from our model for an intervention implemented in Kenya, Malawi, Uganda, and Nigeria without a bundled WASH education component.

**Table 5 - Cost-effectiveness of ceramic water filter manufacture and distribution in Kenya, Malawi, Uganda, and Nigeria**

<table>
<thead>
<tr>
<th></th>
<th>Cost-effectiveness ($/DALY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kenya</td>
<td>74.23</td>
</tr>
<tr>
<td>Malawi</td>
<td>99.95</td>
</tr>
<tr>
<td>Uganda</td>
<td>118.14</td>
</tr>
<tr>
<td>Nigeria</td>
<td>14.88</td>
</tr>
<tr>
<td><strong>AVERAGE</strong></td>
<td><strong>76.80</strong></td>
</tr>
</tbody>
</table>

We did also model the intervention with a bundled WASH education model which you can see in tab “**CEA - With WASH education (Working Model)**”. The endline cost-effectiveness estimates of the models with and without the broader WASH education are very close but suggest that providing filters with only minimal education on how to use and clean them could be slightly more cost-effective than also providing a full WASH education program.
However, we consider the difference between the two estimates too close to discern a conclusive answer among the uncertainties around all the parameters. Therefore, we encourage charities wanting to implement this intervention to explore and evaluate various possibly synergistic combinations of delivering filters and promoting WASH. These might include formats that we have not modeled in our CEA - e.g., community meetings where people both are given filters and watch some WASH demonstrations; delivering leaflets together with filters, etc.

7.4 Comparing the relative cost-effectiveness of chlorination to ceramic filters

Water quality interventions have been well studied by charity evaluators, mostly through GiveWell’s (2022) report focusing on in-line chlorination (ILC) and the Dispensers for Safe Water (DSW). We tried to make our analysis somewhat similar to GiveWell's previous work so that people interested in the cost-effectiveness results can use chlorination interventions as a decent benchmark. However, it is important to bear in mind that the two analyses differ in some aspects, as summarized in Table 6.

Table 6 - Comparison of methodological differences between GiveWell (2022) analysis of chlorination interventions and our analysis of ceramic filters.

<table>
<thead>
<tr>
<th></th>
<th>GiveWell (2022) on chlorination interventions</th>
<th>Present analysis on ceramic water filters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary measure</td>
<td>Primary measure was the risk ratio for all-cause mortality for children under 5 years old and for children and adults 5 years old or older.</td>
<td>Primary measure was the risk ratio for diarrhea episodes among the population of all ages.</td>
</tr>
<tr>
<td>Safe water vessels</td>
<td>Considered outside the scope of the intervention and discounted from the effect through an internal validity adjustment.</td>
<td>Considered an integral part of the intervention and accounted for in the unit cost of delivering the intervention.</td>
</tr>
<tr>
<td>WASH education</td>
<td>Considered outside the scope of the intervention and discounted from the effect through an internal validity adjustment.</td>
<td>Considered outside the scope of the intervention and discounted from the effect through a subgroup analysis of RCTs.</td>
</tr>
</tbody>
</table>
Since those analyses were not directly comparable, we also replicated our filtration analysis with data from chlorination intervention studies from Clasen et al (2015). This analysis of chlorination can be seen throughout our CEA model. Using this data we estimate that ceramic filters are **0.9 to 1.3** times more cost-effective than chlorination in the countries analyzed by GiveWell, as shown in Table 7.

This is promising because it means that filtration is expected to be similarly cost-effective as chlorination, yet it does not need there to be as much existing infrastructure such as water piping or reliable supply chains, and as such can reach people in more deprived areas than chlorination interventions could. This allows us to reach people and provide them with clean water that likely would not have otherwise been targeted by existing water quality interventions.

### Table 7 - Comparison between cost-effectiveness of ceramic filtration vs chlorination

<table>
<thead>
<tr>
<th></th>
<th>Kenya</th>
<th>Uganda</th>
<th>Malawi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost-effectiveness of chlorination ($/moral weight units) - our analysis</td>
<td>$35.39</td>
<td>$52.25</td>
<td>$42.57</td>
</tr>
<tr>
<td>Cost-effectiveness of ceramic filtration ($/moral weight units) - our analysis</td>
<td>$30.44</td>
<td>$40.98</td>
<td>$48.44</td>
</tr>
<tr>
<td>Cost-effectiveness of</td>
<td>1.2</td>
<td>1.3</td>
<td>0.9</td>
</tr>
<tr>
<td>ceramic filtration compared to chlorination</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>------------------------------------------</td>
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</table>
8 Implementation

An implementation section has not yet been written as the scope of this initial research during the research training program was to determine whether the provision of ceramic filters was a promising intervention that was worthy of more attention from either funders or founders starting a new charity. This is different from usual CE reports as we evaluate the promise of an intervention solely for implementation by a new charity.

We will provide a full evaluation of the implementability of this intervention directly to those going through our Incubation Program in the form of an Implementation Report. If you would like to see this section of the Implementation Report, please contact vicky@charityentrepreneurship.com.

In short, this is expected to be quite a simple direct delivery intervention that will improve the lives of its beneficiaries cheaply. As it is not a prohibitively complex intervention, we do not expect talent to be a bottleneck as it should be possible for a talented generalist to work on this issue.

We think that there is room for a new organization working in the space as most existing filtration efforts are small and locally-led. This means that there are many countries and regions that are not covered by existing work and would benefit greatly from a new charity providing free filters.

We also have a few remaining uncertainties with this intervention that could be further explored:

- The impact of this intervention on mortality as we currently only have evidence on the incidence of diarrheal episodes
- Does the size of the family using the filter will impact the filter’s durability?
  - We asked Michael Anyekase, and while he recognized the theoretical reasoning why this could be the case (larger families pour water more frequently), he noted that Pure Home Water does not monitor this and that – intuitively – the effect of family size on durability should be negligible compared to the effects of water turbidity on filter lifespans, but this could be something you test in the field.
- What scale of production is feasible?
○ Unlike chlorine devices, which can be mass-produced and easily transported long distances, ceramic filters must be manufactured locally due to their susceptibility to breakage during transportation. Consequently, the scale of a ceramic filter intervention is likely constrained by the capacity of individual factories to produce filters. **It is currently unclear how large-scale the production of these filters could feasibly be.** Current efforts are in the order of 10,000s so this seems like a realistic aim for a new charity, but we note that many existing organizations are locally-led and have small budgets so perhaps this production capacity could be exceeded by a new charity.

○ In a report by Center for Affordable Water and Sanitation Technology (CAWST 2011), ThirstAid mentions it has taken them “at least two years of training and support to make sure that the manufacturers truly understand the entire process; and that quality, production, and the market can be sustained.” Based on their experience, “Thirst-Aid recommends that new implementers do not start ceramic filter production unless they are willing to maintain a long-term presence and are certain of a sustainable market.” This is simply one report, but something that needs to be considered in the ToC. However, the stated the cost for ceramic ranged from $8 to $19, which indicates that even despite this they were able to sell the ceramic filters at low costs. **We have tried to capture this longer set-up time in our adjustments to the CEA where we have modeled that it takes 3.5 years to reach scale, where in other CEAs we usually assume that it will take only 2 years.**

○ When seeking opportunities within global health there is often a [trade off between cost-effectiveness and scalability](#) with more cost-effective interventions being harder to scale. A well optimized global health space needs both highly cost-effective low or slow to scale organizations and larger scale but less cost-effective organizations. Given the high cost-effectiveness of this intervention **we believe that a ceramic water filter charity should be founded even if it is a slow intervention to scale.**

* How much do the different effect sizes for chlorination and filtration depend on adherence?
● Chlorination generally has lower adherence than filtration in studies, so this could explain the difference in effect sizes. If this is the case, we should be especially concerned about low adherence.

○ Should we include broader WASH education in the theory of change?

● This should ultimately be a decision made by the co-founders of a new charity based on the specific context of the country they decide to work in. They could perhaps run a study where in one arm they provide broader WASH education and in the other they just provide minimal education of filter use so that they can determine whether the broader education model is worth it.

○ How would making households pay a subsidized cost for the filters impact usage?

● This should also be a decision made by the co-founders of a new charity based on the specific context of the country they decide to work in. They could perhaps run a study where in one arm they provide filters for free and in another they provide cheap filters at a subsidized cost so that they can determine whether paying for a filter increases the usage.

○ Are there any unanticipated behavioral limitations to using ceramic filters that will decrease adherence?

● This should be a consideration when doing country scoping visits to determine where to set up your intervention.

○ Uncertainties in modeling based on GiveWell's models: GiveWell has some remaining uncertainties about the way that they have modeled the impacts of chlorination interventions. These uncertainties would also apply to our assessment as we have deferred to GiveWell's methodologies and assumptions in most cases.

● Baseline consumption in beneficiary populations: “Our estimate of the benefit of averting medical costs is sensitive to our estimate of baseline

31 We speculate that the reason filtration devices were found to be more cost-effective could be related to higher adherence among filtration interventions when compared to chlorination. Adherence in chlorination studies included in Clasen et al. (2015) ranged from 32 to 90%, as measured by residual chlorine, with 5 out of 13 trials that reported adherence rates being below 60%. In ceramic filtration studies, adherence ranged from 55 to 100%, with adherence below 60% in only 1 out of 8 trials with reported adherence rates.
consumption. We currently use nation-level data from the World Bank, but these estimates are not specific to beneficiary populations. Further desk research may allow us to refine these estimates somewhat, but direct estimates from implementing organizations would be ideal.”

(GiveWell, 2022)

○ Development effects: “We currently do not have strong direct evidence on the impact of water quality interventions on income later in life, and our estimate of this benefit is therefore highly uncertain. We believe we will need additional evidence to refine our estimate of this parameter, ideally direct evidence from long-term follow-up studies of water quality RCTs. We have not yet investigated the feasibility of such a study.”

(GiveWell, 2022)
9 Conclusion

This report investigated the potential of providing ceramic water filters as a cost-effective intervention to improve water quality and reduce waterborne diseases in low and lower-middle-income countries (LMICs).

Our findings suggest that this approach holds significant promise. This intervention is expected to be highly cost-effective and can reach people in more deprived areas. It is expected to be similarly cost-effective as other water quality interventions (such as chlorination), yet it does not need there to be as much existing infrastructure such as water piping or reliable supply chains, and as such can reach people in more deprived areas.

Overall, we believe that the distribution of locally manufactured ceramic water filters in LMICs is a promising and cost-effective approach for a new charitable initiative.