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1 **SUPPORTING INFORMATION: Adherence to point-of-use water treatment**
2 **over short-term implementation: parallel crossover trials of flocculation-**
3 **disinfection sachets in Pakistan and Zambia**

4
5 Shaheed, A.¹, Rathore, S.², Bastable, A.³, Bruce, J.¹, Cairncross, S.¹, Brown, J.^{4*}

6 ¹Department of Disease Control, Faculty of Infectious and Tropical Diseases, London
7 School of Hygiene & Tropical Medicine, Keppel Street, London WC1E 7HT, United
8 Kingdom

9 ²Mehran University of Engineering and Technology, Jamshoro, Sindh 76062, Pakistan

10 ³Oxfam GB, Oxfam House, John Smith Drive, Oxford, OX4 2JY, United Kingdom

11 ⁴School of Civil and Environmental Engineering, Georgia Institute of Technology

12 *corresponding author.

13 Contact details: School of Civil and Environmental Engineering, Georgia Institute of
14 Technology, 311 Ferst Drive, Atlanta, GA 30332. Tel: +1 (404) 385-4579. Email:
15 joe.brown@ce.gatech.edu

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20 ***Product use***

21 As flocculant-disinfectant sachets intended for batch treatment of water, the two
22 products we tested are similar, but with a few key differences in terms of the specific
23 steps and amount of time for use. Here is an overview:

24

25 **Instructions to users: PoW and Pureit**

26

Product aspects	PoW	Pureit
Volume of water treated / sachet	10L	10L
Stirring time	5 min	2 min
Contact time	25 min	20 min
Order of waiting	Stir, filter and then wait	Stir, wait, and then filter

27

28 **PoW and Pureit use steps**

PuR: Add product to 10 l water → stir 5 min → let stand 5 min → filter through cloth into container → let stand 20 min → consume

Pureit: Add product to 10 l water → stir 2 min → let stand 20 min → filter through cloth into container → consume

29

30 **Sample size**

31 We conducted a literature review to inform the detectable difference to assess between
32 the two products as well as the overall level of adherence to expect. Among the most
33 relevant studies was a two-month longitudinal POU usage trial by Albert and colleagues
34 in Kenya¹. Adherence (defined as the fraction of treated water with *E.coli*
35 concentrations <1 colony forming unit/100mL) was highest in the first week of the
36 study (at 60%), and dropped to 40% within the first month (a 33% reduction), where it
37 remained relatively stable through the second month. Albert and colleagues (2010)
38 assessed three products (a filter, liquid chlorine, and a flocculant-disinfectant), finding
39 flocculant-disinfectant usage to be the lowest¹.

40
41 The first step to our calculation was based on the methods outlined by Diggle et al
42 (2002), and Leon (2004) to analyse binary outcomes with repeated observations^{2, 3}.
43 Equation 3.1 was used to calculate the required number of participants for a two arm
44 trial over four repeat observations. In light of our study using two flocculant-
45 disinfectants, and in order to remain conservative, an initial adherence level of 50%
46 was set, powered to detect a 20% difference between products, and an intraclass
47 correlation coefficient (ICC) of 0.1. This calculation yielded 126 households required
48 per arm (252 households in total), observed over four visits per household.

49
50 **Equation S1: Sample size equation based on Diggle et al. (2002) and Leon (2004) to analyse**
51 **binary outcomes with repeated observations:**

$$52 \quad m = \frac{(\frac{z_{\alpha} \sqrt{2pq} + z_{\beta} \sqrt{p_A q_A + p_B q_B})^2 (1 + (n - 1)\rho)}{2}}{nd^2}$$

53 Where:

- 54 $Z_{\alpha/2}$ = Z value at $\alpha = 0.05$
- 55 Z_{β} = Z value at $(1-\beta) = 0.8$
- 56 p_A = response rate for group A
- 57 p_B = response rate for group B
- 58 $q_A = 1 - p_A$
- 59 $q_B = 1 - p_B$
- 60 $p(\text{bar}) = (p_A + p_B) / 2$
- 61 $q(\text{bar}) = 1 - p(\text{bar})$
- 62 n = number of observations
- 63 ρ = intraclass correlation coefficient
- 64 d = smallest meaningful difference to
65 be detected
- 66

67 The second step was to bring the crossover design into consideration. Several studies
68 note that crossover designs can substantially increase the statistical efficiency of effects
69 estimates, consequently reducing the required sample size. Though no conclusive
70 estimates of power reduction were identified, it was estimated to be as high as 50%^{4,5}.
71 For this study, a more conservative reduction estimate of 25% was made to the initial
72 assessment of 126 households per arm, leading to 100 households per exposure arm,
73 and 200 households in each country study. As the primary comparison in a crossover
74 design is within the same unit of measurement (i.e., usage in households exposed to
75 PoW and Pureit), the two arms referred to in this calculation actually refer to the
76 different exposures (products) given to the same households at different times (i.e., one
77 month each). Our sample size calculation is thus primarily for 100 households to be
78 followed for four repeat measures, and subsequently exposed to the alternative product,
79 as the second “arm”. However, in order to account for order effects, 100 households
80 were exposed to Pureit before PoW (AB), and a further 100 to PoW before Pureit (BA).
81 It is an advantage of this design that different groups of households could also be
82 compared to each other, including: Pureit vs PoW users in crossover period 1 or 2,
83 respectively, and the total sachet usage of all households to Pureit and PoW (both
84 periods). Finally, in order to account for a 10% potential loss to follow-up and issues
85 with data integrity, at least 220 households were recruited in each site.

86
87 Used sachets were not employed in the sample size calculation as the evidence from
88 studies focusing on flocculant-disinfectant usage varied widely and did not have
89 sufficiently reported details. A number of studies have assessed flocculant-
90 disinfectants⁶⁻⁹, and though sachets were counted in all of them, only one reported on
91 longitudinal sachet adherence over time⁶. Chiller and colleagues² found weekly
92 household usage to rise steadily from 5 to 10 sachets per week over 13 weeks. On the
93 other hand, Luby and colleagues⁹ found average usage to be as high as 21 sachets per
94 week in a 9 month study in Karachi¹⁰. Reller and colleagues (2003) conducted a one
95 year study in Guatemala, finding an average of 6 sachets used per household per week¹¹.
96 Crump and colleagues 20-week study found over 85% of users to have detectable
97 chlorine during weekly scheduled visits, but only 44% during unannounced visits⁸.

102 ***Further product details***

103 Pureit contains the same coagulant (ferric sulfate) and chlorine-based disinfectant
104 (calcium hypochlorite) as PoW. Its most significant departure from PoW is the presence
105 of a chlorine-quenching agent, the details of which are proprietary. Pureit is intended
106 to release a high initial dose of chlorine to induce maximum microbial removal,
107 followed by the delayed action of a chlorine-quenching agent to reduce the free chlorine
108 concentration with the intention of improving taste acceptability. Pureit's developers
109 approximated initial free chlorine concentration to be between 2 - 4 mg/L, dropping to
110 0.5 mg/L between 2 - 5 hours post-treatment due to the chlorine quenching agent. While
111 specifying that concentrations were subject to different source water conditions, water
112 was intended to be safe to consume for 48 hours if safely stored (R. Venkataraghavan,
113 Hindustan Unilever, personal communication). Each 2.5 g sachet is capable of treating
114 10 L of water.

115

116 PoW was developed by Procter & Gamble (P&G) in collaboration with the US Centers
117 for Disease Control and Prevention (CDC). It uses calcium hypochlorite for
118 disinfection, ferric sulfate for coagulation, and also contains a buffer made from clay
119 and a polymer to help control the reaction of the chlorine disinfectant in water. The
120 product comes in a 4 gram sachet that treats 10L of water.

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122 ***Product distribution and implementation***

123 After obtaining their consent, participating households were given tokens and a time
124 and location to receive product training and project supplies. Distribution was
125 conducted in batches, and was assisted by community mobilizers. The central training
126 point in Zambia was a local church that was active in the target zone in community
127 work and education. In Pakistan, trainings took place in every neighborhood, as the
128 community was fully covered, and clearly divided by neighborhood, which were
129 divided along lines of caste. Implementation was designed to broadly replicate the
130 protocol for short-term point-of-use water interventions used by Oxfam and their
131 partner NGOs (*N.Bazew, L.Katsi, S.Baloch Oxfam GB, personal communication*).
132 Training did not go beyond group explanations of product usage, and did not include
133 strong messaging to increase potential behavior change. Households were given
134 thorough explanations on product use, specifically differentiating the two products and

135 all safety information. Households had the freedom to use the products as much or as
136 little as they wished.

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138 A list of all households was compiled after recruitment, and used to randomly allocate
139 households to the first product in such a way as to have two equal arms. All households
140 were also given complementary items to use the product with, as per Oxfam protocol,
141 and in order to ensure comparability of results across households and sites. Supply
142 distribution and data collection took place at the household level, defined as a family
143 unit that shares daily drinking water and live together on a regular basis. This was
144 relatively simple in Zambia where households were physically separate and participants
145 were randomly selected over a wider area. The community selected in Pakistan was
146 fully covered.

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148 ***Supplies***

149 Participating households were given:

- 150 ○ 1 x 10L bucket
- 151 ○ 1 x 1m² cotton cloth
- 152 ○ 1 x 10-12L safe storage container, with a tap for drinking-water and a lid to
153 protect it
- 154 ○ 1 x stirring spoon (wooden or metallic)
- 155 ○ 1 x brochure with pictorial explanations of the given product
- 156 ○ Sufficient sachets of either PoW or Pureit to last one month.

157

158 Each household was given one month's set of the allocated product, at the beginning
159 of each four-week usage phase. Households in Zambia were given 93 sachets per phase
160 (based on 3 sachets/household/day for 31 days). After observing usage in Zambia,
161 households in Pakistan were given 62 sachets per phase (2 sachets/household/day for
162 31 days). Households were asked to retain all used and unused sachets in containers
163 provided for this purpose, and informed that they would be provided more if they ran
164 out.

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Table S1: Somer's D p-values for univariate and bivariate hypothesis tests for three outcomes (per capita consumption, observed weekly sachet usage, and presence of detectable chlorine) across products, visits, and crossover period

Country study: Zambia						
Independent variables:	Per capita consumption (% adherence to Sphere)	Observed weekly used sachets		Total chlorine presence/absence		
	Interpretation	Interpretation		Interpretation		
PRODUCT (univariate level)	0.91	Not different across products	0.67	Not different across products	0.006	Different across products
Stratified by: Crossover period 1	0.34	No further difference within periods	0.45	No further difference within periods	0.009	Only different in crossover period 1
Stratified by: Crossover period 2	0.39		0.36			
CROSSOVER PERIOD (univariate level)	<0.001	Different across crossover periods	<0.001	Different across crossover periods	0.049	Different across crossover periods
Stratified by: Product 1 (Pureit)	0.043	Also different within products	0.001	Also different within products	0.56	Borderline difference product 2
Stratified by: Product 1 (Purifier of water)	<0.001		<0.001			
VISIT 1 - 8 (univariate level)	<0.001	Different over all visits	<0.001	Different over all visits	0.13	No difference over visits
Stratified by: Crossover period 1	0.029	Only different in period 1	0.14	Only different in crossover period 1	0.29	Only different in crossover period 2
Stratified by: Crossover period 2	0.36		<0.001			
Country study: Pakistan						
Independent variables:	Per capita consumption (% adherence to Sphere)	Observed weekly used sachets		Total chlorine presence/absence		
	Interpretation	Interpretation		Interpretation		
PRODUCT (univariate level)	0.36	Not different across products	0.14	Not different across products	0.99	Not different across products
Stratified by: Crossover period 1	0.87	No further difference within periods	0.76	No further difference within periods	0.98	No further difference within periods
Stratified by: Crossover period 2	0.47		0.22			
CROSSOVER PERIOD (univariate level)	<0.001	Different across crossover periods	<0.001	Different across crossover periods	0.038	Different across crossover periods
Stratified by: Product 1 (Pureit)	<0.001	Also different within products	<0.001	Also different within products	0.12	No difference after stratifying by product

Stratified by: Product 1 (Purifier of water)	<0.001		<0.001		0.23	
VISIT 1 - 8 (univariate level)	<0.001	Different over all visits	<0.001	Different over all visits	0.53	No difference over all visits
Stratified by: Crossover period 1	0.26	Only different in period 2	0.99	No difference after stratifying by period	0.013	Only different in crossover period 1
Stratified by: Crossover period 2	0.001		0.33		0.85	

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Table S2: Negative binomial regression (Zambia) and zero-inflated negative binomial regression (Pakistan) models testing differences in observed sachet counts per household over crossover period, product, untreated water consumption status and household size.

Country study: Zambia (n=204)					Country study: Pakistan (n=233)					
COVARIATE	Predictor categories (% distribution)	Outcome: Rate of average usage per week			COVARIATE	Predictor categories (% distribution)	Outcome: Rate of average weekly usage per week (non-zero values) and odds of 0 sachets used per week (for 0 values)			
		EFFECT SIZE (IRR*)	95% CI	P-VALUE			EFFECT SIZE*	95% CI	SIGNIFICANCE (p-value**)	
Crossover period	1 (50%)	1			Crossover period	baseline: 1 (50%)	IRR	0.85	0.8-0.91	<0.0001
	2 (50%)	0.7	0.64-0.77	<0.001		2 (50%)	OR	8.6	4.5-16	
Product	Pureit (50%)	1			Product	baseline: Pureit (51%)	IRR	1.04	0.98-1.1	0.37
	Purifier of Water (50%)	1.02	0.93-1.1	0.71		Purifier of Water (49%)	OR	0.98	0.67-1.4	
Untreated water consumption	no (45%)	1			Untreated water consumption	baseline: no (69%)	IRR	0.87	0.8-0.94	<0.0001
	yes (55%)	0.93	0.84-1.04	0.21		yes (31%)	OR	1.7	1.2-2.4	
Household size		1.02	1-1.04	0.05	Household size		IRR	1.02	1-1.04	0.038
							OR	0.98	0.9-1.07	

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* Every outcome for a given independent variable in the zero-inflated negative binomial models is associated with *two* components: IRRs for all positive integers (i.e sachet counts ≥ 1), and odds ratios (ORs) comparing the odds of 0 sachets to ≥ 1 sachets (i.e. representing the odds of no sachets being used, reported as “non-usage” in this manuscript).

** Wald’s p-values including both components of the zero-inflated model (IRR and ORR)

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Table S3: Summary of observed and self-reported consumption (daily frequency averaged across each visit) and households with reportedly treated water at all visits

	ZAMBIA		PAKISTAN	
Observed	N (HH visits)	%	N (HH visits)	%
0	105	7	222	13
<1	850	54	547	31
1+	615	39	981	56
Total	1570	100	1750	100
Stated				
0	5	0.5	0	0.5
<1	395	24.5	113	6
1+	1196	75	1676	93.5
Total	1596	100	1789	100
	N (total households)	%	N (total households)	%
Percentage households reporting water during all of their visits	185	4%	232	19%

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Table S4: Median adherence measures per weekly visit (observed weekly sachets, observed daily sachet usage rate, adherence to Sphere guidelines, and comparison of observed and self-reported daily usage rates)

ZAMBIA	Media n	Range	Media n	Range	Media n	Range	Media n	Range	Media n	Range	Media n	Range	Media n	Range		
Weekly usage per visit	6	0-47	6	0-52	5	0-64	6	0-51	3	0-23	4	0-26	5	0-48	4	0-28
Daily per capita per visit	0.75	0-5.9	0.85	0-8.5	0.86	0-10.7	1	0-8.5	0.6	0-4.4	0.6	0-6.5	0.63	0-5.8	0.57	0-4
Adherence percentage to SPHERE per visit	52	0-500%	57	0-1133%	57	0-1066%	70	0-800%	40	0-420%	46	0-400%	44	0-581%	44	0-414%
Percentage of household visits with water with detectable chlorine per visit	29	-	34	-	29	-	23	-	44	-	25	-	23	-	18	-
stated 1 or more	74	-	78	-	77	-	70	-	66	-	70	-	78	-	86	-
observed 1 or more	36	-	44	-	46	-	53	-	29	-	37	-	35	-	34	-
liters per capita	1.3	0-13	1.4	0-28	1.4	0-27	1.7	0-20	1	0-10	1.1	0-10	1.1	0-15	1.1	0-10
	Visit 1		Visit 2		Visit 3		Visit 4		Visit 5		Visit 6		Visit 7		Visit 8	
PAKISTAN	Media n	Range	Media n	Range	Media n	Range	Media n	Range	Media n	Range	Media n	Range	Media n	Range	Media n	Range
Weekly used sachets/household/visit	10	0-50	8	0-40	8.5	0-37	9	0-34	6	0-50	5	0-46	4	0-38	6	0-44
Daily used sachets/household/visit	1.4	0-7	1.2	0-5	1.2	0-5.2	1.3	0-4.3	0.65	0-5.2	0.75	0-6.3	0.71	0-5.4	0.85	0-6.7
% adherence to SPHERE consumption guidelines	105%	0-857%	100%	0-960%	95%	0-529%	100%	0-850%	44%	0-485%	57%	0-700%	57%	0-1085%	70%	0-1333%

% households with detectable chlorine	78%	-	65%	-	71%	-	64%	-	43%	-	48%	-	47%	-	56%	-
% Stated adherence ≥ 1 sachet/capita/day	97%	-	97%	-	95%	-	98%	-	97%	-	87%	-	89%	-	89%	-
% Observed adherence ≥ 1 sachet/capita/day	76%	-	71%	-	65%	-	67%	-	39%	-	40%	-	42%	-	47%	-
Median treated water consumed (L/person/day)	2.60	0-21	2.50	0-24	2.30	0-13	2.50	0-21	1.10	0-12	1.40	0-18	1.40	0-27	1.70	0-33

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