

Authors
Amy Pickering
Tufts University

Sammy Njenga Kenya Medical Research Institute (KEMRI)

Audrie Lin University of California, Berkeley

Ben Arnold University of California, Berkeley

Christine Stewart University of California, Davis

Clair Null Mathematica Policy Research

1	Integrating water, sanitation, handwashing, and nutrition interventions to reduce child sol-
2	transmitted helminth and Giardia infections: a duster-randomized controlled trial in rural
3	Kenya
4	
5	Amy J. Pickering ^{1,2} *, Sammy M. Njenga ² , Lauren Steinbaum ² , Jenna Swarthout ^{1,4} , Audrie Lin ¹ ,
6	Benjamin F. Arnold ¹ , Christine P. Stewart ⁴ , Holly N. Dentz ^{1,2} , MaryAnne Mureithi ⁴ , Benard
7	Chierg ¹ , Marlene Wolfe ¹⁴ , Ryan Mahoney ⁴ , Jimmy Kihara ¹ , Kendra Byrd ⁵ , Gouthami Rao ⁴ ,
8	Theodora Meerkerk ⁴ , Priscah Cherulyot ⁴ , Marina Papaiakovou ¹⁸ , Nils Pilotte ⁷ , Steven A.
9	Williams ² , John M., Colford, Jr. ⁵ , Clair Null ⁴⁸
10	
11	1 Civil and Environmental Engineering, Tufts University, Mediford, MA, USA, 02155
12	2 Civil and Environmental Engineering, Stanford University, Stanford, CA, USA, 94305
13	3 Kenya Medical Research Institute, Nairobi, Kenya, 34567-00100
14	4 Innovations for Poverty Action, Kakamega, Kenya, 73427-00200
15	5 Division of Epidemiology, School of Public Health, University of California, Berkeley, CA, USA,
16	94720
17	6 Department of Nutrition, University of California, Davis, CA, USA, 95616
18	7 Smith College, Northampton, MA, USA, 01063
19	8 Department of Life Sciences, Natural History Museum, London, UK, SW7 580
20	9 Genter for International Policy Research and Evaluation, Mathematica Policy Research,
21	Washington DC, USA, 20002
22	
23	Correspondence to: Amy J. Pickering, Civil and Environmental Engineering, Tufts University, 11
24	Anderson Hell, 200 College Avenue, Medford, MA 02155, amy pickering@tufts.edu.
25	
26	Short title: Integrated WASH and child parasite infections
27	Trial registration: ClinicalTrials.gov NCT01704105,
28	https://clinicaltrials.gov/ct2/show/NCT01704105

Integrating water, sanitation, handwashing, and nutrition interventions

1

to reduce child soil-transmitted helminth and Giardia infections: a clusterrandomized controlled trial in rural Kenya

Background: Helminth and protozoan infections affect >1 billion children globally. Improved water, sanitation, handwashing, and nutrition could be more sustainable control strategies for parasite infections than mass drug administration (MDA), while providing other quality of life benefits. Methods and Findings: We enrolled geographic clusters of pregnant women into a cluster-randomized controlled trial that tested six interventions: disinfecting drinking water(W), improved sanitation(S), handwashing with soap(H), combined WSH, improved nutrition(N), and combined WSHN. We assessed intervention effects on parasite infections by measuring Ascaris lumbricoides, Trichuris trichiura, hookworm, and Giardia duodenalis among individual children born to enrolled mothers and their older siblings (ClinicalTrials.gov NCT01704105). We collected stool specimens from 9077 total children in 622 clusters, including 2346 children in control, 1117 in water, 1160 in sanitation, 1141 in handwashing, 1064 in WSH, 1072 in nutrition, and 1177 in WSHN. In the control group, 23% of children were infected with Ascaris lumbricoides, 1% with Trichuris trichuria, 2% with hookworm and 39% with Giardia duodenalis. After two years of intervention exposure, Ascaris infection prevalence was 18% lower in the water treatment arm (95% confidence interval (CI) 0%, 33%), 22% lower in the WSH arm (CI 4%, 37%), and 22% lower in the WSHN arm (CI 4%, 36%) compared to control. Individual sanitation, handwashing, and nutrition did not significantly reduce Ascaris infection on their own, and integrating nutrition with WSH did not provide additional benefit. Trichuris and hookworm were rarely detected, resulting in imprecise effect estimates. No intervention reduced Giardia. Reanalysis of stool samples by quantitative polymerase chain reaction (qPCR) confirmed the reductions in Ascaris infections measured by microscopy in the WSH and WSHN groups. Lab technicians and data analysts were blinded to treatment assignment, but participants and sample collectors were not blinded. The trial was funded by the Bill & Melinda Gates Foundation and USAID. Conclusions: Our results suggest integration of improved water quality, sanitation, and handwashing could contribute to sustainable control strategies for Ascaris infections, particularly in similar settings with recent or ongoing deworming programs. Water treatment alone was similarly effective to integrated WSH, providing new evidence that drinking water should be given increased attention as a transmission pathway for Ascaris. Clinical trial registration ID #NCT01704105.

November 09, 2018