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## Articles

## Effects of water quality, sanitation, handwashing, and nutritional interventions on diarrhoea and child growth in rural Kenya: a cluster-randomised controlled trial

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## Summary

**Background:** Poor nutrition and exposure to faecal contamination are associated with diarrhoea and growth faltering, both of which have long-term consequences for child health. We aimed to assess whether water, sanitation, handwashing, and nutrition interventions reduced diarrhoea or growth faltering.

**Methods:** The WASH Baseline cluster-randomized trial enrolled pregnant women from villages in rural Kenya and collected data on 1 year and 2 years of follow-up. We identified 1000 women from 100 clusters. We conducted an active cohort of household visits to measure mid-upper arm circumference, passive coastal data collection only, or compound-level interventions including household visits to promote hand behaviors: drinking chlorinated water (point); safe sanitation consisting of disposing feces in an improved latrine (sanitation); handwashing with soap (handwashing); cooked water, sanitation, and handwashing; controlling so appropriate maternal, infant, and young child feeding plus small quantity lipid-based nutrient supplements from 6–24 months (nutrition); and 2 combined interventions: handwashing and nutrition. Primary outcomes were categories reported during the 1- and 2-year follow-up for: (1) *WASH* length for age Z-score, (2) *WASH* weight for age Z-score, (3) *WASH* weight for height Z-score, and (4) *WASH* length for height Z-score. All children cluster-level data were analyzed. Data were not possible for data collection, but analyses were masked. Analysis was by intention to treat. This trial is registered with ClinicalTrials.gov, number NCT01870415.

**Outlets:** Between years 27, 28 and May 21, 2014, 520 fish in 762 devices were identified and randomly assigned an intervention or control group. 1787 waters were assigned to the active control group; 738 in passive control, 706 to water 70 to sanitation, 767 to handwashing, 732 to combined water, sanitation, and handwashing, 547 to nutrition, and 511 to combined water, sanitation, handwashing, and nutrition. Data on diarrhoea at year 1 for year 1 were available for 520 waters, for year 2 for 497 waters, and for year 3 for 477 waters. Data on diarrhoea at year 1 for year 2 were measured at year 2). Adherence indices for sanitation, handwashing, and nutrition were more than 70% at year 1, handwashing fell below 70% in years 2 and 3, and the water use was less than 45% at year 1 and less than 25% at year 2. Combined groups were comparable to single groups. Water use, the interventions related diarrhoea prevalence and the adherence indices were significantly different between groups. Water use was significantly higher in the combined water, sanitation, and handwashing groups, and combined water, sanitation, and nutrition were higher in year 2 [mean difference 0.31 (95% CI 0.08–0.25)] in the nutrition group; 0.34 (95% CI 0.07–0.27) in the combined water, sanitation, handwashing, and nutrition group; 0.34 (95% CI 0.07–0.27) in the combined water, sanitation, and handwashing groups, and combined water, sanitation, and handwashing had no effect on longer growth.

**Intervention:** Behaviour change messaging combined with technologically simple interventions such as water treatment, household sanitation upgrades from unimproved to improved latrines, and hand-washing stations did not reduce childhood diarrhoea or improve growth, even when adherence was at least as high as has been achieved by other programmes. Counselling and supplementation in the nutrition group and combined water, sanitation, handwashing, and nutrition interventions led to small growth benefits, but there was no advantage to integrating water, sanitation, and handwashing with nutrition. The interventions might have been more efficacious with higher adherence or in an environment with lower baseline sanitation coverage, especially in this context of high diarrhoea prevalence.

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An estimated 176 million children worldwide suffer from stunting (slow growth faltering) and are unlikely to reach their full potential as adults. Linear growth faltering

is the most apparent sign of chronic undernutrition and is the physical manifestation of combined physiological and developmental trends. Early-life stunting leads to poor cognitive development in childhood, reduced

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### Supplementary appendix

This appendix formed part of the original submission and has been peer reviewed.  
We post it as supplied by the authors.

Supplement to: Null C, Stewart CP, Pickering AJ, et al. Effects of water quality, sanitation, handwashing, and nutritional interventions on diarrhoea and child growth in rural Kenya: a cluster-randomised controlled trial. *Lancet Glob Health* 2018; published online Jan 29. [http://dx.doi.org/10.1016/S2214-109X\(18\)30005-6](http://dx.doi.org/10.1016/S2214-109X(18)30005-6).

# Effects of water quality, sanitation, handwashing, and nutritional interventions on diarrhoea and child growth in rural Kenya: a cluster-randomised controlled trial

**Background** Poor nutrition and exposure to faecal contamination are associated with diarrhoea and growth faltering, both of which have long-term consequences for child health. We aimed to assess whether water, sanitation, handwashing, and nutrition interventions reduced diarrhoea or growth faltering.

**Methods** The WASH Benefits cluster-randomised trial enrolled pregnant women from villages in rural Kenya and evaluated outcomes at 1 year and 2 years of follow-up. Geographically-adjacent clusters were block-randomised to active control (household visits to measure mid-

upper-arm circumference), passive control (data collection only), or compound-level interventions including household visits to promote target behaviours: drinking chlorinated water (water); safe sanitation consisting of disposing faeces in an improved latrine (sanitation); handwashing with soap (handwashing); combined water, sanitation, and handwashing; counselling on appropriate maternal, infant, and young child feeding plus small-quantity lipid-based nutrient supplements from 6–24 months (nutrition); and combined water, sanitation, handwashing, and nutrition. Primary outcomes were caregiver-reported diarrhoea in the past 7 days and length-for-age Z score at year 2 in index children born to the enrolled pregnant women. Masking was not possible for data collection, but analyses were masked. Analysis was by intention to treat. This trial is registered with ClinicalTrials.gov, number NCT01704105.

**Findings** Between Nov 27, 2012, and May 21, 2014, 8246 women in 702 clusters were enrolled and randomly assigned an intervention or control group. 1919 women were assigned to the active control group; 938 to passive control; 904 to water; 892 to sanitation; 917 to handwashing; 912 to combined water, sanitation, and handwashing; 843 to nutrition; and 921 to combined water, sanitation, handwashing, and nutrition. Data on diarrhoea at year 1 or year 2 were available for 6494 children and data on length-for-age Z score in year 2 were available for 6583 children (86% of living children were measured at year 2). Adherence indicators for sanitation, handwashing, and nutrition were more than 70% at year 1, handwashing fell to less than 25% at year 2, and for water was less than 45% at year 1 and less than 25% at year 2; combined groups were comparable to single groups. None of the interventions reduced diarrhoea prevalence compared with the active control. Compared with active control (length-for-age Z score  $-1.54$ ) children in nutrition and combined water, sanitation, handwashing, and nutrition were taller by year 2 (mean difference  $0.13$  [95% CI  $0.01$ – $0.25$ ] in the nutrition group;  $0.16$  [ $0.05$ – $0.27$ ] in the combined water, sanitation, handwashing, and nutrition group). The individual water, sanitation, and handwashing groups, and combined water, sanitation, and handwashing group had no effect on linear growth.

**Interpretation** Behaviour change messaging combined with technologically simple interventions such as water treatment, household sanitation upgrades from unimproved to improved latrines, and handwashing stations did not reduce childhood diarrhoea or improve growth, even when adherence was at least as high as has been achieved by other programmes. Counselling and supplementation in the nutrition group and combined water, sanitation, handwashing, and nutrition interventions led to small growth benefits, but there was no advantage to integrating water, sanitation, and handwashing with nutrition. The interventions might have been more efficacious with higher adherence or in an environment with lower baseline sanitation coverage, especially in this context of high diarrhoea prevalence.

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