Implications of WASH Benefits trials for water and sanitation

Authors' reply

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We appreciate the thoughtful comments from Oliver Cumming and Val Curtis and from Diane Coffey and Dean Spears regarding the Kenya and Bangladesh WASH Benefits trials.[1,2] Since both trials took place in populations with relatively low levels of open defecation at enrolment, we agree that the global health community should be cautious about transporting effect estimates from the trials to populations with high levels of open defecation, or to populations in urban environments with vastly different conditions. These trials were done in populations that were similar to much of rural Bangladesh and Kenya, and were chosen explicitly because of the high burden of both linear growth faltering and diarrhoea.[3] We anticipate that the results will be generalisable to many similar rural populations with persistent growth faltering. Forthcoming trial results from Zimbabwe[4] and Mozambique[5] will complement the WASH Benefits trials by providing evidence of the effect of water, sanitation, and handwashing (WASH) interventions on growth in populations with high baseline levels of open defecation, and—in the case of Mozambique—in a high-density, urban setting.

The letters propose that WASH interventions could have possibly improved child growth had we fielded the trials in populations with higher levels of open defecation or in populations with worse drinking water sources. Yet, linear growth faltering prevailed: average length-for-age z-scores (LAZ) in control groups at the final endpoint were –1·54 in Kenya and –1·79 in Bangladesh. Low average LAZ despite low levels of open defecation and access to improved water sources for the majority of people in both populations show that prenatal or postnatal exposures, or both, beyond open defecation and water source are important determinants of linear growth faltering.[6] In Kenya, water supply remained a challenge because few participants had piped water to their homes, but in Bangladesh tube wells within household compounds were ubiquitous, suggesting that adequate water supply alone will be insufficient to prevent growth faltering.

Both letters suggest that a more comprehensive, community-level approach to improving the environment might be necessary to influence child growth. In theory, this is certainly possible, but the trials delivered compound-level interventions because formative research in rural Bangladesh and sub-Saharan Africa showed that, among children younger than 18 months, exposure to faecal contamination occurs primarily within the compound.[7,8] Despite delivering intensive compound-level WASH interventions, it remains possible that the trials did not reduce faecal exposure among children enrolled in the study sufficiently to influence growth through the hypothesised subclinical pathways,[9] despite improving many other outcomes. High diarrhoea prevalence in the Kenya trial[2] and widespread enteric pathogen infection in Bangladesh[10] and Kenya (Pickering AJ, Tufts University, personal communication) reflect high levels of transmission. Environmental measurements in the Bangladesh trial documented widespread faecal contamination that was strongly associated with the presence of animals and their faeces.[11] Forthcoming results from both trials will summarise intervention effects on enteric pathogens and on faecal contamination throughout the children's environment, including complementary foods.

Well designed and conducted randomised trials answer specific

	Population (n)	Mean LAZ (SD)	Difference (95% CI)	p value	Adjusted* difference (95% CI)	p value
Kenya trial control group†						
No improved latrine	1737	–1·58 (1·08)	ref		ref	
Access to improved latrine	364	–1·33 (1·08)	0·25 (0·12–0·37)	<0·001	0·15 (0·02–0·28)	0·02
Bangladesh trial control group†						
No latrine	513	–1·89 (0·98)	ref		ref	
Latrine with no water seal	391	–1·86 (1·00)	..		..	
Latrine has functional water seal	199	–1·37 (1·01)	0·52 (0·34–0·70)	<0·001	0·22 (0·03–0·40)	0·02

Median age 25 months for Kenya trial and 22 months for Bangladesh trial. LAZ=length-for-age z-scores. *Adjusted by use of ensemble machine learning with double-robust, targeted maximum likelihood estimation following the same methods from the prespecified adjusted analyses in the trials. Prespecified, baseline covariates included: child age, child sex, household food insecurity, birth order, maternal age, maternal education, maternal height, number of children and total individuals living in the compound, distance to water, and a broad set of household characteristics and assets. The computational notebook that created the table includes additional analysis details, plus adjusted effects using generalised linear models that resulted in similar estimates (https://osf.io/qkgp8). Data used to make the table are available on the Open Science Framework website for Bangladesh (https://osf.io/wvyn4) and Kenya (https://osf.io/uept9). †In the Kenya trial, improved sanitation was defined as the presence of a latrine with a slab following the standard WHO/UNICEF Joint Monitoring Program definition. In the Bangladesh trial, improved sanitation was defined as a toilet with a functional water seal. These definitions mirrored those reported in the original trials.

Table: **LAZ among children in the control groups of the WASH Benefits trials in Kenya and Bangladesh, stratified by whether the child's household had improved sanitation at enrolment** questions with high validity—a feature that is at once valuable and limiting. It will never be possible to do randomised trials in every setting, and fielding a randomised trial that delivers even more intensive environmental interventions than WASH Benefits to entire communities rather than compounds would probably be logistically and financially prohibitive. Observational analyses could potentially help fill the evidence gap.

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Yet, a re-analysis of the trials leads us to urge the global community to be cautious when interpreting observational analyses of the effects of sanitation on child growth, similar to those presented by Coffey and Spears. Inspired by an analysis that the SHINE investigators[4] presented at the American Society for Tropical Medicine and Hygiene 2017 conference, we re-analysed data from the WASH Benefits trials to estimate the difference in LAZ associated with improved sanitation access at enrolment among children born into the control group—creating an observational, prospective cohort nested within each trial. Among children in the control group, improved sanitation was associated with 0·15 LAZ increase in Kenya (p=0·02) and 0·22 LAZ increase in Bangladesh (p=0·02) in adjusted, double-robust analyses (table). The inconsistency between the observational analyses and null effects in the trials, estimated in the same study populations, illustrates the danger of bias from unmeasured confounding in observational studies, which has been shown in many other examples.[12] It also calls into question whether the observed associations between sanitation conditions and linear growth in India are causal. Sanitation facilities and open defecation practices are inextricably tied to many improvements in overall wellbeing. This cautionary example highlights the value of randomised trials for measuring the effects of exposure–outcome relationships that are deeply entwined with broader socioeconomic development. Nevertheless, we feel strongly that these findings should not diminish ongoing, ambitious efforts to achieve the UN Sustainable Development Goals (SDGs): myriad health, equity, and ethical arguments motivate elimination of open defecation and ample supply of microbiologically safe water, even in the absence of a strong link to child growth.

We declare no completing interests.

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