Effect of a behaviour change intervention on household food hygiene practices in rural Bangladesh: a cluster-randomised controlled trial

Shafinaz Sobhan[1,2*], Anna A. Müller-Hauser[1,2], Giorgia Gon[3], Tarique Md. Nurul Huda[4,5], Jillian L. Waid[2,6], Amanda S. Wendt[2], Mahbubur Rahman[5], Sabine Gabrysch[1,2,6]

[1] Charité – Universitätsmedizin Berlin, corporate member of Freie Universität Berlin and Humboldt-Universität zu Berlin, Institute of Public Health, Berlin, Germany

[2] Research Department 2, Potsdam Institute for Climate Impact Research (PIK), Member of the Leibniz Association, Potsdam, Germany

[3] Department of Infectious Disease Epidemiology, London School of Hygiene and Tropical Medicine, London, United Kingdom

[4] Department of Public Health, College of Public Health and Health Informatics, Qassim University, Al Bukairiyah, Saudi Arabia

[5] Environmental Interventions Unit, Infectious Diseases Division, icddr,b, Dhaka, Bangladesh

[6] Heidelberg Institute of Global Health, Heidelberg University, Heidelberg, Germany

***Correspondence to:**
Shafinaz Sobhan, Institute of Public Health, Charité – Universitätsmedizin Berlin, corporate member of Freie Universität Berlin and Humboldt-Universität zu Berlin, Charitéplatz 1, 10117 Berlin, Germany; **shafinaz.sobhan@charite.de**

ORCiD identifier

Shafinaz Sobhan: 0000-0002-5679-0027
Anna A. Müller-Hauser: 0000-0002-8031-2404
Giorgia Gon: 0000-0002-9741-7712
Tarique Md. Nurul Huda: 0000-0002-9934-0739
Jillian L. Waid: 0000-0001-7668-4179
Amanda S. Wendt: 0000-0001-6019-1900
Sabine Gabrysch: 0000-0002-7081-0506

ABSTRACT

Introduction: Behavioural interventions could improve caregivers' food hygiene practices in low-resource settings. So far, evidence is limited to small-scale and short-term studies, and few have evaluated the long-term maintenance of promoted behaviours. We evaluated the effect of a relatively large-scale behaviour change intervention on medium and long-term maintenance of household food hygiene practices in Bangladesh.

Methods: We analyse a secondary outcome of the Food and Agricultural Approaches to Reducing Malnutrition (FAARM) cluster-randomised trial and its sub-study Food Hygiene to reduce Environmental Enteric Dysfunction (FHEED), conducted in Habiganj district, Sylhet division, Bangladesh. The FAARM trial used a 1:1 parallel arm design and included 2,705 women in 96 settlements: 48 intervention and 48 control. Women in the intervention settlements received training in homestead gardening, poultry rearing and nutrition over three years (2015-2018), complemented by an eight-month (mid-2017 to early-2018) behaviour change component on food hygiene using motivational drivers. Nested within the FAARM trial, the FHEED sub-study evaluated several outcomes along the hygiene pathway. For this article, we evaluated household food hygiene behaviours by analysing structured observation data collected in two cross-sectional surveys, four and 16 months after the food hygiene promotion ended, from two independent subsamples of FAARM women with children aged 6-18 months. We assessed intervention effects on food hygiene practices using mixed-effects logistic regression, accounting for clustering. In exploratory analyses, we further assessed behaviour patterns – how often critical food hygiene behaviours were performed individually, in combination and consistently across events.

Results: Based on the analysis of 524 complementary feeding and 800 food preparation events in households from 571 participant women, we found that intervention households practised better food hygiene than controls four months post-intervention, with somewhat smaller differences after 16 months. Overall, the intervention positively affected food hygiene, particularly around child feeding: using soap for handwashing (odds ratio 5·8, 95% CI 2·2-15·2), cleaning feeding utensils (3·8, 1·9-7·7), and cooking fresh/reheating food (1·8, 1·1-2·8). However, the simultaneous practice of several behaviours was rare, occurring in only 10% of feeding events (intervention: 15%; control: 4%), and the practice of safe food hygiene behaviours was inconsistent between events.

Conclusion: Our findings suggest that a motivational behaviour change intervention encouraged caregivers to maintain certain safe food hygiene practices in a rural setting. However, substantial physical changes in the household environment are likely needed to make these behaviours habitual.

Trial registration number NCT02505711

Keywords Behavioural maintenance, Structured observation, Handwashing, Complementary feeding, Nutrition-sensitive intervention.

1. Introduction

Hygiene during food preparation, feeding, and storage is as essential for young children's growth and nutrition as an adequate and diverse diet (Dewey and Adu-Afarwuah, 2008). Intestinal infections and diarrhoeal disease in children caused by pathogens transmitted in food is a global public health concern, particularly in low-and middle-income countries (LMICs) (Kirk et al., 2017). In economically disadvantaged communities in LMICs, most food contamination and recurrent foodborne infections originate at the household level, primarily from exposure to faecal pathogens in the domestic environment and caregivers' poor food hygiene practices (Curtis et al., 2000). Interventions that aim to interrupt the transmission of pathogens to children in these settings focus largely on reducing direct human contact with faecal pathogens, with particular attention to safe human faeces disposal and handwashing with soap after defecation (Ejemot-Nwadiaro et al., 2021; Humphrey et al., 2019; Luby et al., 2018; Null et al., 2018; Wolf et al., 2022). Even though unwashed hands before handling food, use of unclean feeding utensils, and inadequate reheating of leftovers with poor storage practice remain critical entry points for children's intake of (re)contaminated food in a contaminated environment (Islam et al., 2013; Motarjemi et al., 1993; Parvez et al., 2017), improving caregivers' food hygiene behaviours has only recently received attention in water, sanitation and hygiene (WaSH) and nutrition literature (Curtis et al., 2011).

Over the last decade, a few intervention trials have attempted to improve caregivers' food hygiene practices around complementary child feeding in low-income settings of South Asia and sub-Saharan Africa (Gautam et al., 2017; Manjang et al., 2018; Morse et al., 2020; Mumma et al., 2019). They employed behavioural models to understand motivational drivers, and the interventions focused on a wide range of behaviour change techniques such as commitment, modification in the domestic environment, use of prompts and cues, and social rewards to encourage the adoption of safe food hygiene behaviours among mothers and caregivers of young children (Gautam et al., 2017; Manjang et al., 2018; Morse et al., 2019; Simiyu et al., 2020). While the success of these trials in improving targeted behaviours was promising (Chidziwisano et al., 2020a; Gautam et al., 2017; Manaseki-Holland et al., 2021), most of the interventions were of limited scale and short duration (Gautam et al., 2017; Manjang

et al., 2018) and implemented with frequent contacts with participants (Gautam et al., 2017; Morse et al., 2020). Evidence about long-term behavioural maintenance in response to such interventions is also limited, to our knowledge, reported only in one food hygiene study in The Gambia (Manaseki-Holland et al., 2021).

Concurrent with other food hygiene studies, we designed a less intensive behavioural intervention to promote food hygiene as part of a larger nutrition-sensitive agriculture trial in Bangladesh. During follow-up visits during the implementation phase, we noted a substantial increase in all promoted food hygiene behaviours compared to the pre-intervention period (Sobhan et al., 2022). Nevertheless, it remained to be seen whether these behaviours could be maintained long-term. Furthermore, safe food preparation, consumption and feeding children are complex processes involving several critical points (Islam et al., 2013) and practising multiple food hygiene behaviours together might be required to substantially minimise the risk of food contamination (Müller-Hauser et al., 2022). Also, these behaviours need to be practised repeatedly during every preparation and feeding event to achieve optimal impact on child health. However, how often multiple food hygiene behaviours are practised simultaneously and consistently remains an open question.

In this article, therefore, we primarily aimed to evaluate the effect of this relatively large-scale, less intensive behavioural intervention on the maintenance of household food hygiene practices at four and sixteen months after the intervention. In exploratory analyses, we also assessed the behavioural patterns to expand our understanding about (a) variations in the practice of several food hygiene behaviours during food preparation and child feeding and (b) consistency in food hygiene practices across multiple observed events.

2. Materials and methods

2.1. Study design and participants

This analysis was conducted to evaluate a pre-specified secondary outcome of the Food and Agricultural Approaches to Reducing Malnutrition (FAARM) cluster-randomised controlled trial (ClinicalTrials.gov, ID: NCT02505711) and its sub-study: Food Hygiene to reduce Environmental Enteric Dysfunction (FHEED). Details of the FAARM trial design, setting, participants and information about the FHEED sub-study can be found in the published protocol (Wendt et al., 2019). In summary, the FAARM trial (2015-2019) was set up to evaluate the impact of a homestead food production (HFP) program on child undernutrition and growth in two rural sub-districts of Habiganj district, Sylhet division, Bangladesh. It enrolled 2,705 married women aged 30 years or younger in 96 settlements (geographic clusters of 10-65 women living close to each other) who expressed interest in homestead gardening and had access to at least 40m^2 of land. Settlements were then randomised (1:1) using covariate-constrained randomisation, with 48 clusters assigned to receive a three-year HFP intervention and 48 to controls. The HFP intervention, implemented by Helen Keller International from mid-2015 to late-2018, promoted the consumption of diverse and nutrient-rich foods, especially among women and children, through vegetable gardening, poultry rearing and nutrition counselling. In its third year, an additional behaviour change component promoting good food hygiene was introduced and implemented over eight months (mid-2017 to early-2018) with an aim to complement the benefits of nutrient-rich and diverse diets in improving child nutrition with reduced food contamination and intestinal infections. Consequently, in 2018, the FHEED sub-study was added to the FAARM trial to specifically collect and analyse data on multiple outcomes along the hygiene-infection-nutrition pathway more elaborately, from adoption of household food hygiene behaviours to complementary food contamination, enteric infection, and inflammation in children. This article evaluated the intervention effect on the maintenance of household food hygiene behaviours among women with (index) children aged 6-18 months.

2.2. Food hygiene component: content and delivery

Adapting a food hygiene intervention package implemented in Nepal, we designed a behaviour change component within the FAARM intervention to promote four food hygiene behaviours: 1) handwashing with soap and water; 2) washing utensils with soap and water; 3) cooking food fresh or thoroughly reheating stored food; and 4) safe storage of cooked food and drinking water. We focussed on emotional drivers of hygiene behaviours (e.g. nurture, disgust, affiliation, and pride) and adopted several behaviour change techniques to address knowledge, instrumental and experiential beliefs, personal agency, and social norms drivers of the intended behaviours. The package contained fun and participatory activities in four group sessions and four household visits, implemented over eight months. An overview of the design, implementation and content of the FAARM food hygiene component has been published previously (Sobhan et al., 2022) and is summarised in Table S1.

2.3. Data collection procedure

We evaluated the post-intervention maintenance of promoted food hygiene behaviours in two cross-sectional structured observations from two independent sub-samples of FAARM women with children aged 6-18 months. The first structured observation took place in July-September 2018, approximately four months after the food hygiene promotion ended, and all women with a child born between January and December 2017 were eligible to participate. The second structured observation took place exactly one year later, in July-August 2019, approximately 16 months post-intervention, and all women with a child born between April and December 2018 were eligible to participate. However, women who had already participated in the 4-month structured observation for an older child were excluded from the 16-month observation.

A trained female observer conducted a 3-hour direct observation in each woman's household in the morning or early afternoon. During an observation session, she focussed mainly on two critical events: (i) child feeding – observing the mother (FAARM women) or another adult family member feeding the (index) child a meal or a snack; (ii) food preparation and serving - observing the mother or another adult family member cooking family meals (e.g. rice, lentils, vegetables, curry) or preparing a special meal for the child or serving meals and snacks to family members. The food hygiene practices around child

feeding and food preparation were recorded on a structured paper form. If more than one feeding, cooking, or serving event occurred during the observation, each event was recorded separately. At the end of each observation day, all collected information was transferred to a tablet-based Open Data Kit questionnaire (Hartung et al., 2010).

The socio-demographic characteristics of the participating women and their households were extracted from trial data: women's age, education, religion, and households' wealth and WaSH-related characteristics from the FAARM baseline survey conducted in March-May 2015; (index) children's age and sex from the FAARM surveillance records collected shortly after each child's birth; and the current number of household members from the information as reported by the women during structured observation. Women's education was categorised based on completed school years: no formal education, primary (1-5 years of schooling), or secondary education (6+ years of schooling). Household wealth was calculated based on each household's asset information collected during the FAARM baseline survey to determine their position within the national wealth quintile of the Bangladesh Demographic and Health Survey 2014, using EquityTool (www.equitytool.org). Access to an improved water source (e.g. tube well, public tap), sanitation facilities (e.g. pit latrine, flush or pour-flush flush latrine) and handwashing facilities were defined following the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP) classifications (World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), 2017).

2.4. Sample size

The sample size for structured observation was determined solely based on the expected number of women with children aged 6-18 months at both points. Based on the FAARM routine assessment conducted every two months, we estimated that around 400 women with a child in this age group would be eligible to participate in the 4-month structured observation, with 200 women in each group. We calculated that with this sample size, we could detect a 15% absolute difference in the proportion of mothers (25% in the intervention vs 10% in control) performing all food hygiene behaviours with 90% power and a design effect of 1·5. However, due to time and resource limitations, we only included women with children aged 6-15 months for 16-month structured observation. Consequently, the estimated sample size is smaller, with approximately 130 women in each group.

2.5. Blinding

Given the nature of the intervention, it was impossible to keep the implementation team and women in the intervention group blinded to the intervention activities. However, a minimum distance of 400m was maintained between two neighbouring settlements to limit any spillover to control settlements. An independent team, not involved in the implementation process or aware of the settlement allocation, carried out the structured observations at both time points. To minimise reactivity bias during structured observation, the observers informed participants that they would record household activities without disclosing their interest in food hygiene behaviours.

2.6. Outcomes

We specified four primary outcomes for this analysis: 1) handwashing with soap before handling food; 2) washing utensils with cleaning agent before use; 3) cooking fresh or reheating foods before serving; 4) storing cooked foods with lids and on a raised shelf/inside a cabinet (see Table 1 for definitions). Besides, we also evaluated two composite measures as secondary outcomes: *any handwashing* and *using clean utensils*. Any handwashing involves adhering to at least one of the two actions: (a) washing one hand with soap and clean water or (b) washing both hands using only clean water. We included washing both hands with clean water as this could also substantially reduce bacterial contamination of hands compared to not washing them at all (Burton et al., 2011; Luby et al., 2011). Using clean utensils entails adhering to at least one of the three utensil cleanliness measures: (a) washing utensils with a cleaning agent right before use, (b) using visibly clean utensils after rinsing them thoroughly with clean water or (c) using pre-washed utensils from a clean, elevated place. We included washing utensils with clean water and using pre-washed utensils from a clean place, as similar measurements for clean utensils were assessed in other food hygiene studies. (Chidziwisano et al., 2020a; Islam et al., 2013; Manaseki-Holland et al., 2021; Touré et al., 2013). Other secondary outcomes we measured were the overall cleanliness of the kitchen and food preparation area and the presence of a functional handwashing facility near the kitchen (Table 1).

2.7. Statistical Analysis

We first analysed and compared the socio-demographic characteristics of the participants between intervention and control groups at baseline, using proportions for categorical variables and means and standard deviations for continuous variables. Next, we compared the observed food hygiene practices between the two groups and the two observation time points. We summarised the findings using proportions and absolute percentage point differences accounting for settlement-level clustering. The effects of the food hygiene component on individual food hygiene behaviours were evaluated using mixed-effects logistic regression models with repeat measures. However, the smaller sample size and infrequent occurrence of certain behaviours during the 16-month observation made it challenging to fit these outcomes into a regression model and evaluate the intervention effect as a stand-alone evaluation. Therefore, we combined the 4-month and 16-month structured observations into a single dataset to increase the frequency of individual outcomes and improve the statistical power for measuring the effect. We fitted mixed-effects logistic regression models with a random effect for settlement-level clustering and fixed effects for temporal variations (4-month or 16-month) for each outcome. We calculated predicted probabilities using marginal standardisation and effect estimates as odds ratios with corresponding 95% confidence intervals (CIs). Analyses were stratified by child feeding and food preparation events to determine variations in food hygiene practices by occasion. Analyses were intention-to-treat.

In sensitivity checks, we conducted the following analyses: 1) We replicated the models adjusting for (slight) imbalance in wealth quintiles at baseline and child age measured in completed months. 2) We ran the models separately for 4-month structured observation only (first only with a random effect for settlement and then again adjusted for baseline wealth quintiles and child age) to assess any differences in the effect estimates that could arise from combining two distinct observations that ook place at different time points.

Finally, to evaluate behaviour patterns, we focused on two aspects. First, we assessed the simultaneous practice of three critical food hygiene behaviours (i.e. washing hands, using clean utensils, and cooking/reheating food) during a child feeding or serving event. We grouped the combinations as ‘all three behaviours performed together’, ‘any two performed together’, ‘one performed alone’, or ‘none’.

Next, we evaluated the consistency in food hygiene practices only among women for whom we recorded two serving events. Observing their food hygiene practices in both events, we assessed the frequency of each behaviour on a scale of 'never', 'either one time', or 'repeated both times'. For both analyses, we combined 4-month and 16-month structured observations to increase the sample size and only included feeding and serving meal events (excluding snacking events). All analyses were conducted in Stata version 17.

2.8. Ethical considerations

The FAARM trial protocol was positively reviewed by Heidelberg University in Germany (Ref.: S-121/2014) and the James P. Grant School of Public Health, BRAC University in Bangladesh (Ref.: 37A). The FHEED study protocol was positively reviewed by Heidelberg University (Ref.: S-606/2017) and icddr,b in Bangladesh (Ref.: PR-17126). All participants provided informed written consent when they enrolled in the trial and additional verbal consent before data collection.

3. Results

Overall, we present results from 571 FAARM women and their households (intervention: 292, control: 279) who participated in one of the two cross-sectional structured observations, representing 86% of 668 eligible women with children aged 6-18 months. Fig. 1 illustrates the flowchart of participants, including reasons for exclusion from structured observations and analysis at each time point.

Table 2 describes the socio-demographic characteristics of the sample at baseline in 2015, disaggregated by intervention and control groups and structured observation time points. Both groups were broadly similar regarding baseline women's age, educational attainment, religion, and household size. The mean age of women was 23 years, and about half had completed some years of primary education. About three-quarters of households were Muslim, and the remaining were Hindu. On average, seven people lived in one household. There was a slight difference in baseline wealth between groups, as around 38% of intervention households were in the top two wealth quintiles compared to only 30% in the control group. This imbalance could be traced to small differences in household assets and amenities, such as higher ownership of agricultural land and marginally better house construction in intervention households (Table S2). Regardless, in terms of water, sanitation and hygiene infrastructure and facilities, the difference between the two groups was very minimal: in both groups, about one-third of households had access to an improved water source on their premises, two-fifths had an improved latrine, and less than one-tenth had a functional handwashing facility near the kitchen. At baseline, reported handwashing with soap varied from ~30% before child feeding to ~40% before food preparation. The mean age of the (index) children, extracted from the FAARM birth surveillance record, was 13 months in the 4-month structured observation and 11 months in the 16-month observation.

3.1. A comparative analysis of food hygiene practices between groups and observation time points

We analysed food hygiene practices from 524 child feeding (intervention: 270; control: 254) and 800 food preparation and serving events (intervention: 412; control: 388), primarily performed by the mother (89% and 86%, Table S3). Table 3 presents descriptive statistics of food hygiene outcomes for intervention and control households, separately by 4-month and 16-month structured observation. During the 4-month structured observation, intervention households had better food hygiene practices

than controls; they used clean utensils in 91% of child feeding events (71% in control) and cooked fresh or reheated stored food before serving in 58% of events (45% in control). Handwashing with soap was also higher in the intervention group, with the frequency being low overall (intervention: 12%; control: 3%). Even when both hands rinsed only with water were counted alongside washing hands with soap, the observed frequency of handwashing before child feeding was below 25%. Around one-quarter of intervention households had a functional handwashing facility near the kitchen compared to 16% in controls. We observed a similar pattern of food hygiene practice during food preparation events as during child feeding. Among the four primary outcomes, only storing cooked food with a cover and on a raised shelf was less prevalent among households in the intervention group (29%) compared to controls (38%); however, the evidence is relatively weak, and the difference could be due to chance.

During the 16-month structured observation, the observed practice of most food hygiene behaviours in intervention households remained largely the same as during the 4-month round, whilst some practices had also increased in controls (Table 3). At the 4-month observation, the frequency of using clean utensils for food preparation was higher in intervention households (71%) than in controls (57%), while at 16 months, it was higher and similar in both groups (intervention: 94%; control: 95%). Likewise, serving fresh or reheated food to a family member was similar between groups at 16 months, while serving fresh or reheated food to children was still slightly higher in intervention (72%) than in control (64%) (Table 3). Table S4 details the frequency of food hygiene practices, kitchen, and WaSH-related characteristics.

3.2. Effect of the intervention on household food hygiene practices

Table 4 shows the predicted probabilities and overall intervention effects estimated from 4-month and 16-month structured observations combined. We found positive effects of the intervention on several food hygiene practices related to child feeding: handwashing with soap (odds ratio (OR) 5·8, 95% confidence interval (CI) 2·2-15·2), washing feeding utensils with soap (OR 3·4, CI 1·3 -8·8), and cooking fresh or reheating stored food (OR 1·8, CI 1·1-2·8). We also observed similar effects in the context of food preparation.

Given the slight imbalance in baseline household wealth between intervention and control groups, as sensitivity analysis, we assessed the overall effects on each behaviour, adjusting for baseline wealth and

child age and found no substantive changes in the effect estimates compared to the primary models. Similarly, we assessed the intervention effects on each outcome exclusively for the 4-month structured observation to evaluate any differences in the effect estimates that could arise from combining observations from two different time points. Again, we found no noteworthy differences in the effect estimates (Table S5).

3.3. Behaviour patterns in observed food hygiene practices: exploratory analyses

Our exploratory analyses to understand behaviour patterns highlighted that simultaneous practice of multiple food hygiene behaviours during a child feeding or food preparation event was uncommon, and safe behaviours were not consistently or repeatedly followed across different events. Out of 462 child feeding events, in only 45 occasions (overall 10%; intervention: 15%; control: 4%), all three critical behaviours (i.e. washing hands, using clean utensils, and serving fresh/reheated food) were carried out together whereas in 31 events (~7%), none of the behaviours were observed. Cooking fresh or reheating foods and using clean utensils were more commonly practised together than any other combination: occurred before 39% of child feeding events and 31% of serving events (Fig. 2A & 2B). Fig. 3 demonstrates the consistency in food hygiene practices for 99 women (intervention group only) whose food hygiene behaviours were observed two times on two occasions. Even though more than three-fourths of them used clean utensils at both events, few consistently washed their hands before feeding or serving food: only 5% washed their hands at both times and 25% at least in one of two observed events (see Table S6 and Table S7 for a detailed breakdown of the frequency and proportion by intervention group).

4. Discussion

This trial is one of few to investigate the impact of a behaviour change intervention on medium and long-term maintenance of multiple food hygiene practices around complementary child feeding. We conducted two cross-sectional structured observations one year apart, approximately four months and 16 months after implementation. The observed frequency of several recommended food hygiene behaviours was substantially greater in intervention households after four months, and most behaviours remained higher than in controls after 16 months. Overall, the intervention showed positive effects on three of the four recommended behaviours: washing hands with soap, using clean feeding utensils, and cooking fresh or reheating stored food, especially before feeding to young children. However, handwashing with or without soap before handling food was very low overall, and practice of several food hygiene behaviours at once was rare.

So far, results from three randomised controlled trials evaluating food hygiene interventions in three developing countries have been published. The three-month behaviour change intervention in Nepal found that the practice of all five promoted food hygiene behaviours was more common among mothers in the intervention group (43%) than controls (2%) 45 days after the study ended (Gautam et al., 2017). The trial in The Gambia assessed the impact in two long-term post-intervention evaluations and found that adherence to all targeted behaviours was substantially better in intervention villages (65%) than in controls (15%) six months post-intervention. However, the difference between the two groups decreased after 32 months (47% vs 40%) (Manaseki-Holland et al., 2021). A concurrent behaviour change intervention in Malawi also showed immediate improvement in three of the four promoted food hygiene behaviours following nine months of intervention (Chidziwisano et al., 2020a).

Similar to the other three trials, our study found mothers and family members in intervention households were more than three times as likely to use clean utensils and twice as likely to cook fresh or reheat stored food, especially before feeding young children, compared to the control households. Handwashing with soap before food preparation and child feeding was also substantially more frequent in the intervention households (OR: 5.8) but was rarely and inconsistently practised: it was observed in around 12% of child feeding (controls 3%) and only 5% of food preparation events (controls: 1%). Even

handwashing without soap was rare, practised in less than a quarter of observations. This frequency is much smaller than what has been seen for handwashing with soap in Nepal (intervention: 67%; control: 5%) (Gautam et al., 2017), The Gambia (intervention: 46-64%; control: 4-19%) (Manaseki-Holland et al., 2021) and Malawi (intervention: 43-47%; control: 0-0·6%) (Chidziwisano et al., 2020a). To alleviate concerns that the slight imbalance in wealth between the two groups biased our findings in favour of better food hygiene practices in intervention households, we undertook a sensitivity analysis which adjusted for baseline wealth quintile and found no substantial change in the effect estimates.

In our study, despite overall household wealth not being a determining factor in practising safe food hygiene behaviours, the absence of direct water connection and soap in most households' kitchens was likely the primary reason for low hand washing. During our post-intervention evaluation, we did observe some improvement in the availability of functional handwashing facilities near the kitchen in intervention households: it increased from 6% at baseline to 21% after food hygiene promotion, nevertheless, it remained much lower than reported in other food hygiene studies in The Gambia and Malawi. In The Gambia, about 90% of intervention households had soap in their kitchens during the post-intervention evaluation (Manaseki-Holland et al., 2021), and in Malawi, more than half of intervention households had a handwashing facility with soap and water conveniently located close to the kitchen (Chidziwisano et al., 2020b). On the other hand, in the Nepal study, more than 50% of study households had access to piped water on compounds, and 40% had tap water inside the house (Gautam et al., 2017). Even though more than 80% of our study households had access to a tube well (hand pump), with ~60% located on-premises, most were set at some distance from the kitchen and living unit. Therefore, it is not surprising that the effort of walking to the tube wells to wash hands or constantly refilling the handwashing bucket several times a day may have made handwashing, even simply rinsing hands under water, too cumbersome for the mothers or household members – as this behaviour needs to be performed dozens of times a day, after every instance of recontamination. On the same note, washing feeding utensils with clean water, which only needs to be done a few times a day, was more frequently practised than handwashing with water (~60% vs ~13% of child feeding events). This contrast between the two behaviours suggests that the proximity of the water source to the kitchen was

not the only obstacle to handwashing; frequency may also have played a role in determining their enactment. Research showed that when a behaviour is viewed as too challenging due to a difficult context, people may lack the motivation to perform it repeatedly (Ouellette and Wood, 1998). Interaction with water while rinsing utensils may also have altered caregivers' intention to wash their hands properly by giving them the satisfaction of cleaning hands at the same time, as reported in a previous study in Bangladesh (Nizame et al., 2016).

Safe food storage (cooked food fully covered with lids and stored on a raised shelf) was the only behaviour that showed no overall difference between the intervention and control groups. However, at least part of the message had been taken up more in intervention households than in the controls: more intervention households stored food on an elevated shelf (69% vs 59% in control), but pots were often uncovered or only partially covered (54% vs 51% in control). More freshly cooked and reheated food was left uncovered than previously cooked food – probably due to the typical practice of allowing food to cool before storing it and lack of covered shelves or mesh food covers – suggesting that more frequent fresh preparation and reheating of leftovers in intervention households than controls could have offset better safe food storage behaviour in our setting.

Even though most food hygiene behaviours in intervention households remained unchanged between the 4-month and the 16-month observation, the differences between the two groups reduced and hence diminished the intervention effects as several practices (especially using clean utensils and serving fresh food/reheating leftovers) had also increased in control households at 16 months. The food hygiene study in The Gambia reported similar fade-out effects on certain food hygiene practices by 32 months post-intervention, apparently due to cross-contamination from intervention villages (Manaseki-Holland et al., 2021). In our study, some control households may have received food hygiene information from families or relatives who participated in the FAARM intervention. However, to our knowledge, such family connections between participants of the two groups were not common. Besides, due to limited mobility, visiting friends and relatives was also not a frequent social activity for these women (Waid et al., 2022). Therefore, exchanging information during family visits may have partly influenced better practices among the control group but likely does not fully explain the marked increase. Seasonality

cannot explain this increase either, as both observations took place at the same time of year. Although the smaller sample size and fewer observed events during the 16-month observations led to less power to detect differences between the two groups, explaining the improvement in some food hygiene practices among control households remains difficult.

Our exploratory analyses revealed that the simultaneous and consistent practice of multiple food hygiene behaviours was rare. Several factors could lead to such suboptimal behaviour patterns. First, in a rural Bangladeshi household, cooking, washing hands and utensils, and food storage happen in different places – some inside and some outside the kitchen and living unit. The distance between the cooking/dining area and the water source with poorly equipped kitchens can make it difficult for mothers to perform all behaviours simultaneously. Inadequate support within the household could also have overwhelmed them with different household chores and caring for children and the elderly and limited their ability to adopt, practice and continue the behaviours simultaneously and consistently across the day. Finally, preparing meals or feeding a child and following multiple food hygiene behaviours is itself a complex process involving many sub-actions. In resource-poor settings, this means more effort, time and deliberate attention for mothers and caregivers to ensure that each activity is performed at the right time(s). This continuous thinking of when to act may have led them to struggle with holding their positive intentions, properly completing the safe practices, and, more importantly, carrying those out repeatedly. While we noted an effect of the intervention in the expected direction, with intervention households exhibiting better food hygiene practices than controls, the fact that most of these behaviours were only practised infrequently or inconsistently offers more clarity on why these improvements may have been insufficient to reduce food contamination (Huda et al., to be published) and, therefore, likely had no impact on diarrhoea and EED, as noted in our separate analyses in two recently published articles (Lambrecht et al., 2023; Müller-Hauser et al., 2023).

Our study had several strengths. We directly observed mothers' and other household members' food hygiene practices, which is more objective and reliable than self-reported practice, as socially desirable behaviours like food hygiene are commonly over-reported (Chidziwisano et al., 2020b). To our knowledge, this is the second randomised controlled trial evaluating medium and long-term intervention effects on household food hygiene behaviours. Our rich household observation data also allowed us to

better describe the patterns of food hygiene behaviours, including how they were adopted independently, in combination, and maintained over time.

A few limitations should be mentioned as well. A single 3-hour observation in each household limited the feeding events observed and may have prevented us from recording less common food hygiene practices in some households. However, as the frequency of observed events was similar in the intervention and control groups, this should hardly bias our impact estimates. Despite our best efforts to conduct the observations in a natural setting, the presence of an observer might have led to reactivity bias (Gittelsohn et al., 1997). Given the low observed handwashing frequency, such bias also seems unlikely. Finally, we conducted this study in only two rural sub-districts in north-eastern Bangladesh. Nevertheless, the poor household conditions and suboptimal food hygiene practices resemble numerous rural villages in Bangladesh and other similar settings in South Asia and sub-Saharan Africa, supporting the generalisability of our findings.

5. Conclusions

Behaviour change strategies in a low-intensity intervention can motivate caregivers to improve food hygiene around complementary child feeding. However, the still low handwashing frequency and suboptimal pattern of food hygiene behaviours suggest that without a substantial change in the physical environment (e.g. piped water inside the kitchen), these interventions may not enable caregivers to practice these behaviours consistently. Much remains to be done for a better understanding of complex interlinked factors, including the influence of social networks and norms, the perceived complexity of behaviours, and constraints in terms of cost, effort, and infrastructure, as well as the effectiveness of different intervention approaches that could promote the maintenance of multiple food hygiene behaviours in a resource-poor setting.

Authors' contributions

SG is the principal investigator of the FAARM trial and FHEED study. SG, AAM, and TNH conceived and designed the FHEED study and acquired funding. SS, AAM, and TNH developed all data collection tools with guidance from GG, ASW, and other members of the study team. SS and TNH managed the FHEED field team in Bangladesh and supervised data collection. JLW led the data management of the entire FAARM trial, including the FHEED data, and prepared the initial datasets for this study. SS analysed the data, prepared, and interpreted the results, and wrote the first and subsequent drafts of this article. AAM and GG provided guidance on data analysis and interpretation of results. MR provided general supervisory and management support to the FHEED team in Bangladesh. All authors critically reviewed the manuscript in several steps and approved the final version.

Declaration of interests

We have no competing interests.

Data sharing

A deidentified dataset with the individual participant data that underlie the results reported in this article is available to interested researchers who provide a methodologically sound proposal for use of the data. Data requests with a proposal should be directed to the corresponding author (SS; shafinaz.sobhan@charite.de) and the principal investigator (SG; sabine.gabrysch@charite.de). A data access agreement will need to be signed to gain access to the data. The FAARM trial protocol is available online.

Funding source and their role

The FAARM trial was primarily funded by the German Federal Ministry of Education and Research (BMBF, grant number: 01ER1201). The FHEED study was financially supported by a project grant from Deutsche Forschungsgemeinschaft (DFG, German Research Foundation; Project number: 413269709). Foundation Fiat Panis further supported FHEED's research work. Helen Keller International received additional support from the Carrefour social responsibility program and other charitable donations for implementing the homestead food production program. Sabine Gabrysch received funding through a Recruiting Grant from Stiftung Charité. Funding organizations had no role in the FAARM trial design, the intervention or its implementation, in training, data collection, analysis, or interpretation of results.

Acknowledgements

We sincerely thank all the women and households who participated in this study. We thank our collaborating partners Helen Keller International and icddr,b in Bangladesh; all FHEED data collection team members for their time and effort in conducting the observations; and especially Saheen Hossein for his supportive supervision. We thank Om Prasad Gautam for his invaluable help in designing the food hygiene intervention and Wolf-Peter Schmidt for his advice on developing the FHEED study. We also thank Jesmin Sultana for her contributions to the preparation of the study proposal, data collection tools, and training, and Mahfuza Islam for her kind support during the training. Finally, we thank the German Federal Ministry of Education and Research and Deutsche Forschungsgemeinschaft (DFG) for the financial support.

References

Chidziwisano, K., Slekiene, J., Mosler, H.J., Morse, T., 2020a. Improving complementary food hygiene behaviors using the risk, attitude, norms, ability, and self-regulation approach in rural Malawi. Am. J. Trop. Med. Hyg. 102, 1104–1115. https://doi.org/10.4269/AJTMH.19-0528

Chidziwisano, K., Tilley, E., Morse, T., 2020b. Self-reported versus observed measures: Validation of child caregiver food hygiene practices in rural malawi. Int. J. Environ. Res. Public Health 17, 1–14. https://doi.org/10.3390/ijerph17124498

Curtis, V., Cairncross, S., Yonli, R., 2000. Review: Domestic hygiene and diarrhoea - Pinpointing the problem. Trop. Med. Int. Heal. 5, 22–32. https://doi.org/10.1046/j.1365-3156.2000.00512.x

Curtis, V., Schmidt, W., Luby, S., Florez, R., Touré, O., Biran, A., 2011. Hygiene: New hopes, new horizons. Lancet Infect. Dis. 11, 312–321. https://doi.org/10.1016/S1473-3099(10)70224-3

Dewey, K.G., Adu-Afarwuah, S., 2008. Systematic review of the efficacy and effectiveness of complementary feeding interventions in developing countries. Matern. Child Nutr. 4, 24–85. https://doi.org/10.1111/j.1740-8709.2007.00124.x

Ejemot-Nwadiaro, R.I., Ehiri, J.E., Arikpo, D., Meremikwu, M.M., Critchley, J.A., 2021. Hand-washing promotion for preventing diarrhoea. Cochrane Database Syst. Rev. 2021. https://doi.org/10.1002/14651858.CD004265.pub4

Gautam, O.P., Schmidt, W.P., Cairncross, S., Cavill, S., Curtis, V., 2017. Trial of a novel intervention to improve multiple food hygiene behaviors in Nepal. Am. J. Trop. Med. Hyg. 96, 1415–1426. https://doi.org/10.4269/ajtmh.16-0526

Gittelsohn, J., Shankar, A. V, Wes, K.P., Ram, R.M., Gnywali, T., 1997. Estimating reactivity in direct observation studies of health behaviors. Hum. Organ. 56, 182–189.

Hartung, C., Lerer, A., Anokwa, Y., Tseng, C., Brunette, W., Borriello, G., 2010. Open data kit: Tools to build information services for developing regions, in: Proceedings of the 4th ACM/IEEE International Conference on Information and Communication Technologies and Development, ICTD '10. Association for Computing Machinery, New York, NY, USA, pp. 1–12. https://doi.org/10.1145/2369220.2369236

Humphrey, J.H., Mbuya, M.N.N., Ntozini, R., Moulton, L.H., Stoltzfus, R.J., Tavengwa, N. V., Mutasa, K., Majo, F., Mutasa, B., Mangwadu, G., Chasokela, C.M., Chigumira, A., Chasekwa, B., Smith, L.E., Tielsch, J.M., Jones, A.D., Manges, A.R., Maluccio, J.A., Prendergast, A.J., the Sanitation Hygiene Infant Nutrition Efficacy (SHINE) Trial Team, 2019. Independent and combined effects of improved water, sanitation, and hygiene, and improved complementary feeding, on child stunting and anaemia in rural Zimbabwe: a cluster-randomised trial. Lancet Glob. Heal. 7, e132–e147. https://doi.org/10.1016/S2214-109X(18)30374-7

Islam, Mohammad Sirajul, Mahmud, Z.H., Gope, P.S., Zaman, R.U., Hossain, Z., Islam, Mohammad Shafiqul, Mondal, D., Sharker, M.A.Y., Islam, K., Jahan, H., Bhuiya, A., Endtz, H.P., Cravioto, A., Curtis, V., Touré, O., Cairncross, S., 2013. Hygiene intervention reduces contamination of weaning food in Bangladesh. Trop. Med. Int. Heal. 18, 250–258. https://doi.org/10.1111/tmi.12051

Kirk, M.D., Angulo, F.J., Havelaar, A.H., Black, R.E., 2017. Diarrhoeal disease in children due to contaminated food. Bull. World Health Organ. 95, 233–234. https://doi.org/10.2471/BLT.16.173229

Lambrecht, N.J., Müller-Hauser, A.A., Sobhan, S., Schmidt, W.-P., Huda, T.M.N., Waid, J.L., Wendt, A.S., Kader, A., Gabrysch, S., 2023. Effect of a Homestead Food Production Program on the Prevalence of Diarrhea and Acute Respiratory Infection in Children in Sylhet, Bangladesh: A Cluster-Randomized Controlled Trial. Am. J. Trop. Med. Hyg. https://doi.org/10.4269/ajtmh.23-0152

Luby, S.P., Rahman, M., Arnold, B.F., Unicomb, L., Ashraf, S., Winch, P.J., Stewart, C.P., Begum, F., Hussain, F., Benjamin-Chung, J., Leontsini, E., Naser, A.M., Parvez, S.M., Hubbard, A.E., Lin, A., Nizame, F.A., Jannat, K., Ercumen, A., Ram, P.K., Das, K.K., Abedin, J., Clasen, T.F., Dewey, K.G., Fernald, L.C., Null, C., Ahmed, T., Colford, J.M., 2018. Effects of water quality, sanitation, handwashing, and nutritional interventions on diarrhoea and child growth in rural Bangladesh: a cluster randomised controlled trial. Lancet Glob. Heal. 6, e302–e315. https://doi.org/10.1016/S2214-109X(17)30490-4

Manaseki-Holland, S., Manjang, B., Hemming, K., Martin, J.T., Bradley, C., Jackson, L., Taal, M., Gautam, O.P., Crowe, F., Sanneh, B., Ensink, J., Stokes, T., Cairncross, S., 2021. Effects on childhood infections of promoting safe and hygienic complementary-food handling practices through a community-based programme: A cluster randomised controlled trial in a rural area of the Gambia. PLoS Med. 18, 1–24. https://doi.org/10.1371/journal.pmed.1003260

Manjang, B., Hemming, K., Bradley, C., Ensink, J., Martin, J.T., Sowe, J., Jarju, A., Cairncross, S., Manaseki-Holland, S., 2018. Promoting hygienic weaning food handling practices through a community-based programme: Intervention implementation and baseline characteristics for a cluster randomised controlled trial in rural Gambia. BMJ Open 8. https://doi.org/10.1136/bmjopen-2017-017573

Morse, T., Chidziwisano, K., Tilley, E., Malolo, R., Kumwenda, S., Musaya, J., Cairncross, S., 2019. Developing a contextually appropriate integrated hygiene intervention to achieve sustained reductions in diarrheal diseases. Sustain. 11. https://doi.org/10.3390/su11174656

Morse, T., Tilley, E., Chidziwisano, K., Malolo, R., Musaya, J., 2020. Health outcomes of an integrated behaviour-centred water, sanitation, hygiene and food safety intervention–a randomised before and after trial. Int. J. Environ. Res. Public Health 17, 1–19. https://doi.org/10.3390/ijerph17082648

Motarjemi, Y., Kaferstein, F., Moy, G., Quevedo, F., 1993. Contaminated weaning food: A major risk factor for diarrhoea and associated malnutrition. Bull. World Health Organ. 71, 79–92.

Müller-Hauser, A.A., Huda, T.M.N., Sobhan, S., Lambrecht, N.J., Waid, J.L., Wendt, A.S., Ali, S., Rahman, M., Gabrysch, S., 2023. Effect of a Homestead Food Production and Food Hygiene Intervention on Biomarkers of Environmental Enteric Dysfunction in Children Younger Than 24 Months in Rural Bangladesh: A Cluster-Randomized Controlled Trial. Am. J. Trop. Med. Hyg. https://doi.org/10.4269/ajtmh.23-0153

Müller-Hauser, A.A., Sobhan, S., Huda, T.M.N., Waid, J.L., Wendt, A.S., Islam, M.A., Rahman, M., Gabrysch, S., 2022. Key Food Hygiene Behaviors to Reduce Microbial Contamination of Complementary Foods in Rural Bangladesh. Am. J. Trop. Med. Hyg. 107, 709–719. https://doi.org/10.4269/ajtmh.21-0269

Mumma, J., Simiyu, S., Aseyo, E., Anderson, J., Czerniewska, A., Allen, E., Dreibelbis, R., Baker, K.K., Cumming, O., 2019. The Safe Start trial to assess the effect of an infant hygiene intervention on enteric infections and diarrhoea in low-income informal neighbourhoods of Kisumu, Kenya: A study protocol for a cluster randomized controlled trial. BMC Infect. Dis. 19, 1–11. https://doi.org/10.1186/s12879-019-4657-0

Nizame, F.A., Leontsini, E., Luby, S.P., Nuruzzaman, M., Parveen, S., Winch, P.J., Ram, P.K., Unicomb, L., 2016. Hygiene practices during food preparation in Rural Bangladesh: Opportunities to improve the impact of handwashing interventions. Am. J. Trop. Med. Hyg. 95, 288–297. https://doi.org/10.4269/ajtmh.15-0377

Null, C., Stewart, C.P., Pickering, A.J., Dentz, H.N., Arnold, B.F., Arnold, C.D., Benjamin-Chung, J., Clasen, T., Dewey, K.G., Fernald, L.C.H., Hubbard, A.E., Kariger, P., Lin, A., Luby, S.P., Mertens, A., Njenga, S.M., Nyambane, G., Ram, P.K., Colford, J.M., 2018. Effects of water quality, sanitation, handwashing, and nutritional interventions on diarrhoea and child growth in rural Kenya: a cluster-randomised controlled trial. Lancet Glob. Heal. 6, e316–e329. https://doi.org/10.1016/S2214-109X(18)30005-6

Ouellette, J.A., Wood, W., 1998. Habit and intention in everyday life: The multiple processes by which past behavior predicts future behavior. Psychol. Bull. 124, 54–74. https://doi.org/10.1037/0033-2909.124.1.54

Parvez, S.M., Kwong, L., Rahman, M.J., Ercumen, A., Pickering, A.J., Ghosh, P.K., Rahman, M.Z., Das, K.K., Luby, S.P., Unicomb, L., 2017. Escherichia coli contamination of child complementary foods and association with domestic hygiene in rural Bangladesh. Trop. Med. Int. Heal. 22, 547–557. https://doi.org/10.1111/tmi.12849

Simiyu, S., Czerniewska, A., Aseyo, E.R., Baker, K.K., Cumming, O., Mumma, J.A.O., Dreibelbis, R., 2020. Designing a food hygiene intervention in low-income, peri-urban context of Kisumu, Kenya: Application of the trials of improved practices methodology. Am. J. Trop. Med. Hyg. 102, 1116–1123. https://doi.org/10.4269/AJTMH.19-0629

Sobhan, S., Müller-Hauser, A.A., Huda, T.M.N., Waid, J.L., Gautam, O.P., Gon, G., Wendt, A.S., Gabrysch, S., 2022. Design, delivery, and determinants of uptake: findings from a food hygiene behavior change intervention in rural Bangladesh. BMC Public Health 22:887, 1–18. https://doi.org/10.1186/s12889-022-13124-w

Waid, J.L., Wendt, A.S., Sinharoy, S.S., Kader, A., Gabrysch, S., 2022. Impact of a homestead food production program on women's empowerment: Pro-WEAI results from the FAARM trial in Bangladesh. World Dev. 158, 106001. https://doi.org/https://doi.org/10.1016/j.worlddev.2022.106001

Wendt, A.S., Sparling, T.M., Waid, J.L., Mueller, A.A., Gabrysch, S., 2019. Food and Agricultural Approaches to Reducing Malnutrition (FAARM): protocol for a cluster-randomised controlled trial to evaluate the impact of a Homestead Food Production programme on undernutrition in rural Bangladesh. BMJ Open 9, e031037. https://doi.org/10.1136/bmjopen-2019-031037

Wolf, J., Hubbard, S., Brauer, M., Ambelu, A., Arnold, B.F., Bain, R., Bauza, V., Brown, J., Caruso, B.A., Clasen, T., Colford, J.M., Freeman, M.C., Gordon, B., Johnston, R.B., Mertens, A., Prüss-Ustün, A., Ross, I., Stanaway, J., Zhao, J.T., Cumming, O., Boisson, S., 2022. Effectiveness of interventions to improve drinking water, sanitation, and handwashing with soap on risk of diarrhoeal disease in children in low-income and middle-income settings: a systematic review and meta-analysis. Lancet 400, 48–59. https://doi.org/10.1016/S0140-6736(22)00937-0

World Health Organization (WHO), the United Nations Children's Fund (UNICEF), 2017. Progress on Drinking Water, Sanitation and Hygiene: 2017 Update and SDG Baselines. Geneva, Switzerland.

Tables

Table 1

Definitions of outcome measures.

Primary outcomes

Handwashing with soap
Mother/an adult family members washing at least one hand with soap (including bar soap, liquid soap, powder detergent, and soapy water) and clean water before preparing food and feeding child.

Washing utensils with a cleaning agent
Washing all utensils with cleaning agent (including dishwashing bar, dishwashing liquid, detergent powder) and clean water right before use for food preparation and serving.

Cooking fresh or reheating foods
Cooking family meals (e.g. rice, lentils, vegetables, curry) or a special meal for the child (e.g. khichuri*, porridge) and reheating all stored food before feeding the child or serving it to a family member.

Covering food and store elevated
Storing cooked foods with lids and on a raised shelf/inside a cabinet to protect from flies, insects, and domestic animals.

Secondary outcomes

Any handwashing
Mother/an adult family members was compliant if she adhered to at least one of the two handwashing actions before preparing food and feeding child: (a) washing hands with soap and clean water or (b) washing both hands using only clean water.

Using clean utensils
Mother/an adult family members adhered to at least one of the three utensil cleanliness measures before using them for food preparation and serving: (a) washing utensils with a cleaning agent right before use, (b) using visibly clean utensils after rinsing them thoroughly with clean water or (c) using visibly clean utensils that were stored in a clean, elevated place.

Cleanliness of the kitchen and food preparation area
Kitchen and food preparation area is visibly clean from flies, insects, and animal faeces during observation.

Functional handwashing facility near kitchen †
A fixed or mobile handwashing facility‡ with water and soap (including bar soap, liquid soap, powder detergent, and soapy water) is available inside or near kitchen/food preparation area.

*Khichuri is a soft one-pot dish usually made with rice, lentils, and vegetables and often prepared as complementary food for young children. †Functional handwashing facility was defined following the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP) classifications. ‡In our context, a handwashing facility usually refers to tube wells (hand pumps), sinks with tap water, drums or buckets with taps, tippy-taps, jugs, and buckets/containers with mugs or pouring cups.

Table 2

Characteristics of women and households participating in the food hygiene observations in Habiganj District, Sylhet, Bangladesh

	4-month		16-month	
	Intervention (n=185)	Control (n=181)	Intervention (n=107)	Control (n=98)
Women and children's characteristics				
Age of woman, years	23.2 (±3.8)	22.9 (±4.0)	22.5 (±3.5)	22.7 (±3.7)
Education level				
None	29 (16%)	19 (11%)	17 (16%)	15 (15%)
Primary (Grade 1-5)	82 (44%)	91 (50%)	47 (44%)	46 (47%)
Secondary (≥ Grade 6)	74 (40%)	71 (39%)	43 (40%)	37 (38%)
Age of (index) child, months	12.6 (±3.8)	13.3 (±3.6)	10.9 (±2.8)	10.8 (±2.8)
Sex of (index) child, female	85 (46%)	76 (42%)	54 (50%)	45 (46%)
Household characteristics				
Religion, Muslim	146 (79%)	138 (76%)	80 (75%)	68 (69%)
Household members, average	7.2 (±3.1)	6.4 (±2.1)	6.9 (±2.8)	7.6 (±2.9)
Household wealth, quintile *				
Poorest	14 (8%)	29 (16%)	13 (12%)	11 (11%)
Lower	55 (30%)	57 (32%)	24 (23%)	34 (35%)
Middle	46 (25%)	42 (23%)	28 (26%)	23 (23%)
Upper	58 (31%)	46 (25%)	33 (31%)	24 (25%)
Wealthiest	12 (6%)	7 (4%)	9 (8%)	5 (5%)
Household WaSH characteristics				
Improved water source on premises †	94 (51%)	91 (50%)	52 (49%)	43 (44%)
Access to an improved sanitation facility ‡	71 (38%)	74 (41%)	48 (45%)	32 (33%)
Functional handwashing facility near kitchen §	10 (5%)	9 (5%)	8 (7%)	9 (9%)
Reported handwashing with soap				
Before food preparation	70 (38%)	70 (39%)	36 (34%)	42 (43%)
Before child feeding	74 (40%)	54 (30%)	28 (26%)	29 (30%)

Data are frequency (proportion) or mean (±SD). Data on women, household and WASH characteristics were collected during the FAARM baseline survey in 2015. (Index) child's age and sex were obtained from the FAARM birth surveillance record collected within 72 hours of a child's birth. Information on current household members was collected at the time of observation. *An estimation of the national wealth quintile compared to the Bangladesh Demographic and Health Survey 2014 constructed using www.equitytool.org. †Improved water sources include household piped connections, public standpipes, protected tube wells with a platform, protected dug wells or springs and rainwater collection. ‡An improved sanitation facility refers to flush/pour-flush latrines connected to piped sewer systems, septic tank pit latrines, ventilated-improved pit latrines, pit latrines with a slab and composting toilets which are not shared with other households. §Availability of a fixed or mobile facility with water and soap (including bar soap, liquid soap, powder detergent, and soapy water). Access to an improved water source, sanitation and handwashing facilities were defined following the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP) classifications. Abbreviations: WaSH: Water, sanitation, and hygiene.

Table 3

Comparative analysis of food hygiene practices between intervention groups, by observation round

	4-month			16-month		
	Intervention	Control	Percentage point difference (95% CI)	Intervention	Control	Percentage point difference (95% CI)
Child feeding						
Number of events observed	191	189	..	79	65	..
Washed hands with soap	23 (12%)	5 (3%)	9.4 (4.2-14.5)	9 (11%)	1 (2%)	9.9 (2.2-17.5)
Washed hands (any) *	44 (23%)	16 (8%)	14.6 (7.4-21.7)	11 (14%)	5 (8%)	6.2 (-3.8-16.2)
Washed utensils with soap	19 (10%)	7 (4%)	6.2 (1.2-11.3)	6 (8%)	2 (3%)	4.5 (-2.7-11.7)
Used clean utensils †	174 (91%)	134 (71%)	20.2 (12.6-27.8)	74 (94%)	63 (97%)	-3.3 (-10.1-3.6)
Preparing food before feeding ‡	183	178	..	54	47	..
Cooked fresh or reheated	107 (58%)	80 (45%)	13.5 (3.3-23.7)	39 (72%)	30 (64%)	8.4 (-9.8-26.6)
Food preparation						
Number of events observed	251	231	..	161	157	..
Washed hands with soap	10 (4%)	2 (1%)	3.1 (0.4-5.8)	10 (6%)	1 (1%)	5.6 (1.6-9.5)
Washed hands (any) *	57 (23%)	29 (13%)	10.2 (3.4-16.9)	39 (24%)	25 (16%)	8.3 (-0.4-17.0)
Washed utensils with soap	14 (6%)	5 (2%)	3.4 (0.0-6.8)	10 (6%)	3 (2%)	4.3 (0.0-8.6)
Used clean utensils †	178 (71%)	132 (57%)	13.8 (5.3-22.3)	151 (94%)	149 (95%)	-1.1 (-6.2-4.0)
Preparing food before serving ‡	227	192	..	129	119	..
Cooked fresh or reheated	175 (77%)	127 (66%)	10.9 (2.3-19.6)	93 (72%)	92 (77%)	-5.2 (-16.0-5.6)
Food storage and kitchen environment						
Number of households observed	185	181	..	107	98	..
Food covered and stored elevated	53 (29%)	69 (38%)	-9.5 (-19.1-0.1)	37 (35%)	15 (15%)	19.3 (7.8-30.8)
No insects or animals around storage	70 (38%)	61 (34%)	4.1 (-5.7-13.9)	33 (31%)	18 (18%)	12.5 (0.8-24.1)
Clean kitchen and food preparation area	37 (20%)	35 (19%)	0.7 (-7.5-8.8)	20 (19%)	9 (9%)	9.5 (0.2-18.8)
Functional handwashing facility §	43 (23%)	29 (16%)	7.2 (-0.9-15.3)	17 (16%)	7 (7%)	8.7 (0.1-17.3)

Data are frequency (proportion) of observed food hygiene practices. *A mother/an adult family member adhered to at least one of the two handwashing actions: (a) washed one hand with soap and clean water or (b) washed both hands using only clean water. †A mother/an adult family member adhered to at least one of the three utensil cleanliness measures: (a) washed utensils with a cleaning agent right before use, (b) used visibly clean utensils after rinsing them thoroughly with clean water or (c) used visibly clean utensils stored in a clean, elevated place. ‡Denominators are smaller as they excluded snacking events. §Availability of a handwashing facility with water and soap inside/near kitchen. Abbreviations: CI: Confidence Interval.

Table 4

Intervention effect on food hygiene practices (4-month and 16-month observations combined)

	Predicted probability (%) *		Odds ratio (95% CI)	p value
	Intervention	Control		
Child feeding †	**270**	**254**	··	··
Washed hands with soap	11.7	2.4	5.8 (2.2-15.2)	<0.001
Washed hands (any) ‡	20.9	8.4	3.1 (1.6-6.0)	0.001
Washed utensils with soap	9.6	3.2	3.4 (1.3-8.8)	0.013
Used clean utensils §	92.1	77.8	3.8 (1.9-7.7)	<0.001
Cooked fresh or reheated stored food ¶	61.7	48.7	1.8 (1.1-2.8)	0.013
Food preparation and serving †	**412**	**388**	··	··
Washed hands with soap	4.9	0.8	6.8 (1.9-24.1)	0.003
Washed hands (any) ‡	23.2	13.9	1.9 (1.2-2.9)	0.003
Washed utensils with soap	6.5	2.0	4.2 (1.1-16.1)	0.036
Used clean utensils §	80.6	72.6	1.8 (1.0-3.5)	0.061
Cooked fresh or reheated stored food ¶	75.3	70.6	1.3 (0.8-2.0)	0.241
Food storage †	**292**	**279**	··	··
Food covered and stored on elevated place	30.3	30.0	1.0 (0.6-1.6)	0.958

*Estimated from mixed-effect logistic regression models using marginal standardisation. All models included a random effect for settlement-level clustering and a fixed effects for observation year. †Total observations (n) in the model. ‡A mother/an adult family member adhered to at least one of the two handwashing actions: (a) washed one hand with soap and clean water or (b) washed both hands using only clean water. §A mother/an adult family member adhered to at least one of the three utensil cleanliness measures: (a) washed utensils with a cleaning agent right before use, (b) used visibly clean utensils after rinsing them thoroughly with clean water, or (c) used visibly clean utensils stored in a clean, elevated place. ¶Observations excluded snacking events (for child feeding, total n: intervention 237, control 225); (for food preparation and serving, total n: intervention 356, control 311). Abbreviations: CI: Confidence Interval.