



## Piloting an intervention to improve microbiological food safety in Peri-Urban Mali

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### ABSTRACT

**Introduction:** Diarrhoeal diseases remain a major cause of preventable death among children under five years old in developing countries. Studies related to infant diarrhoea causation have demonstrated a higher level of faecal contamination in weaning foods than in drinking water. Many studies have examined the microbiological quality of such foods, but few of them have resulted in an intervention. The present study builds upon an experiment in which the HACCP approach was applied to preparation of two common weaning foods (*moni* and fish soup) and used to develop simple hygiene measures which mothers could take in preparing and serving foods to their children, to prevent contamination.

**Methods:** A randomly selected sample of 60 volunteer mothers was split into two groups of 30, the first receiving messages promoting implementation of the hygiene measures, and the second as a control. Samples of the food were taken in all 60 households at the point where they would have been served to a child. These were examined microbiologically, and physical parameters were measured. The process was repeated after the mothers had received three weeks' training in the preventive measures, and again three months later on an unannounced visit.

**Results:** Before the intervention, thermotolerant coliform (TTC) contamination levels exceeded 100 per gram in 55% of food samples cooled after cooking (prior to child service) and in 86% of samples of food stored prior to child service. After the intervention, the contamination was detected (i.e. >10 TTC/g) in less than 17% of food samples cooled (prior to child service) after cooking and in only 4% of food samples reheated after storage and cooled prior to child service. The reduction in faecal contamination was highly significant ( $P < 0.0001$ ). The follow-up visit three months later produced still better results; only 0% to 17% of food samples failed to meet our standard of <10 TTC/g.

**Conclusion:** The HACCP approach can lead to effective measures for improving home food safety, and is applicable with modest resources for promotion of food hygiene and safety in a low-income community.

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### Introduction

Diarrhoeal diseases remain a major cause of preventable death among children under five years old in developing countries (Boschi-Pinto et al., 2008). However, interventions to reduce faecal contamination of food have not been fully developed or tested in developing countries (Lanata, 2003). This may be due to the common belief that water is the most important source of diarrhoeal diseases. Indeed, it has been argued that up to 90% of childhood diarrhoea is related to poor sanitation, lack of access to clean water, and inadequate personal hygiene (Keusch et al., 2006). While

public authorities in developing countries were advised to support safe water programs, domestic hygiene promotion (so ran the argument) should focus on human stools disposal and effective hand-washing after stool contact (Curtis et al., 2000).

A recent hygiene review concluded that, "Most of what we assume about food-borne infections in low-income settings is based on expert opinion and biological plausibility, rather than field data" (Curtis et al., 2011). It did not alter the conclusions of the WHO review of the literature on the promotion of food hygiene (Esrey and Feachem, 1989). That review assumed that most food borne disease transmission in developing countries likely takes place within the home, and advocated a major programme of interdisciplinary research to develop and test cost-effective interventions to promote food hygiene. Lanata (2003) strengthened the postulate saying that "Food, not water, may be the most important route of transmission of diarrhoea in less developed countries".

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Curtis et al. (2000) suggested that behaviours preventing stools from contaminating household surroundings (in which the child lives), could have greater impact than practices preventing pathogens from being ingested. However, many studies related to infant diarrhoea have demonstrated that the level of contamination is higher in weaning foods than in drinking water (Barrell and Rowland, 1980; Imong et al., 1989; Henry et al., 1990; Motarjemi et al., 1993; Lanata, 2003; Kung'u et al., 2009). Sheth et al. (2000), in a study in an urban slum in Baroda, India, found that infant diarrhoea incidence remained high due to contaminated foods whilst the drinking water was found to have no coliforms.

The HACCP (Hazard Analysis, Critical Control Point) approach has been developed and widely applied to food hygiene in industrialised countries (Little et al., 2003) and adapted to small businesses (FAO/WHO, 2005). The few studies which have examined its relevance to domestic preparation of food (Griffith and Worsfold, 1994; Ehiri et al., 2001; Sheth et al., 2000) were purely observational, and did not complete the process by implementing an intervention.

We have described elsewhere (Touré et al., 2011) how we developed and tested such an intervention with 15 volunteer mothers of young children in low-income areas of Bamako, Mali. The mothers were taught a set of changes to their procedures for preparation and storage of weaning foods, and supervised to ensure that they carried them out. That might be called a study of efficacy, or proof of concept. However, our ultimate goal must be to assess effectiveness of an intervention feasible at scale.

In the present study, our objective was to pilot test the same measures under conditions closer to those likely in a full-scale hygiene promotion programme, in order to find out their impact on microbial reduction in the food, and their sustainability. In this case, the mothers were taught the corrective measures but not supervised.

## Methods

### Selection of participants

The study participants were selected at three health centres in Commune V, a low-income area of Bamako. Mothers of children aged six to eighteen months, attending nutrition education sessions at their local health centre were asked to volunteer. From a list of 120 volunteer mothers, 60 were randomly selected as the study sample and randomly split into two groups of 30; the first underwent the intervention (delivery of messages directed to the food hygiene measures) and the second served as a control. The sample size was chosen so as to be able to detect a reduction in microbiological contamination in 70% of intervention households, compared with control households.

### Foods chosen for study

Using focus groups, two foods (*moni* and fish soup) were identified in the previous phase as the two major meals used as weaning foods in the study area. Recipes, ingredients, preparation and handling processes were described for each of these (Touré et al., 2011).

*Moni*, made by cooking flour from up to six local cereals (millet, sorghum, maize, peanut, soybean, wheat) mixed with water, is the meal most commonly used locally as a weaning food. The liquid is cooked for about 20 minutes to become the *moni*. Then sugar, milk or lemon and “monkey bread” (fruit of the baobab) is added. The meal is divided into two parts; one part is given immediately to the child (after ten minutes of cooling) and the rest is stored at room temperature for seven to twelve hours and served again, reheated or not, to the child. It is served with a spoon, from a cup or from the utensil containing the meal.

Fish soup is another widely used weaning food in Bamako. It is composed of fresh fish and vegetables – tomato, onion, and lettuce. Fish and vegetables are washed separately at home. The vegetables are ground before putting them in a pot containing water and set on the fire. The fish, cut into small pieces, is added. The preparation is then cooked for 30 to 50 min. Other ingredients are added when the preparation is boiling. The soup is split into two parts, one to feed the child immediately after ten minutes of cooling. The rest is stored until the afternoon, six to seven hours later. The child is fed with a spoon and the mother's hand (to separate fish from bones).

### Content of the intervention

The focus groups also described in detail all the steps of preparation and handling of the two selected foods, from obtaining the produce to feeding the child. Data from focus groups and observation were used to draw and validate a preparation process flow diagram for each food. Bacteriological examination of samples taken from various stages of the preparation process made it possible to carry out a HACCP analysis and identify critical control points (Touré et al., 2011).

This led to selection of the following corrective measures:

- Washing hands with safe running water and soap (including local soap), at the critical moments (before starting meal preparation, feeding children or eating, after cleaning a child's bottom and after using latrines),
- Washing dishes with safe running water and soap (including local soap), using safe water for the preparation of food as well,
- Cooking and reheating foods until boiling, and
- Covering foods with tight-fitting lids during storage.

Cooking and reheating to temperatures above 70 °C for at least 10 min were selected as monitoring criteria.

### Baseline

For the present phase, the 60 volunteer mothers were asked to prepare the same foods at home, and a sample taken from each for bacterial examination. Physical parameters (temperatures of foods, ambient air and in storage room, humidity and pH) were recorded on-site at the time of sampling using a TFX410-1 thermometer, hand-held pH meter model 8601, and hygrometer model TFH 610 (Klipspringer Instrumentation, Ipswich UK) and an ALBA W071 chronometer (Seiko Watch Corporation, Tokyo, Japan). These initial data were used as baseline.

As a compensation for demonstrations of meal preparation and sampling of foods, an amount of 2000 CFA (local currency), approximately £2, was allocated the day before each demonstration session to each mother.

One concern was that the mothers might not reveal their true practices, if they knew the purpose of our intervention (Curtis and Kanki, 1998; Monte et al., 1997). So, at this stage they were informed that our purpose was neither to create a competition between them nor to evaluate their capabilities, but to learn about their weaning food recipes.

### Implementing the intervention

Then the intervention group underwent training and demonstrations to enable each mother to perform the hygiene measures to improve her child's food. Three female graduate field workers liaised with, trained and observed the mothers. Each was in charge of 20 mothers (10 intervention and 10 controls). The field workers trained the mothers of the intervention group during three weeks,

assessing their knowledge and observing them during the whole process.

Mothers' training was organized in three steps. The first was a brief preliminary visit to find and identify the mother's household and to obtain informed consent. The second step involved a more extensive household visit. On this occasion the mother's weaning food preparation practices were observed in order to select relevant messages. The messages included an explanation of what is considered as clean water, where to get it, how to store it safely and a description of boiling. Demonstrations were also given during the training sessions on how to perform corrective actions; washing hands and utensils with clean water and soap.

This visit was in two parts; one in the morning, for "food preparation, handling and child feeding" and one in the afternoon on the same day, for "for handling leftovers and child feeding". The third step was a similar pair of house visits, to check the mothers' understanding of the messages and to recall corrective actions if needed.

Morning visits lasted one to two hours from around 9 am and the afternoon ones about one hour from 3 pm. In total the training period included six to eight hours of contact time, although this was distributed throughout three weeks because field workers were available five days per week, and each had 10 mothers in their charge; their household visits were thus on a 2-week cycle.

#### *Follow-up*

After the training period, fortnightly follow-up visits were continued for nine months. These were used to collect samples of food at critical points. Visits to the control group were limited to those for household identification and sample collection. The follow-up visits also served to monitor the Intervention Group, noting deviations and recommending corrective measures, and to help the laboratory staff with food sampling. Samples were collected from each intervention mother and her counterpart control on the same day.

Mothers were always asked to report constraints they may have faced in implementing corrective actions effectively, and to suggest possible solutions. For instance, some mothers said that they could not afford to buy soap regularly. Thus, a hand washing kit consisting of a water container, a basin and some soap, was provided to all of them by the fieldworkers during the intervention period.

In households where other family members were involved in the child's care, they were also included in message delivery and followed for compliance with corrective actions.

The field worker wrote down all deviations from corrective actions that occurred during a daily observation of the mother's performance in weaning food preparation and handling. At the end of each session, the fieldworker discussed with the mother any observed deviations from corrective actions, and noted the mothers' explanations and their suggestions if any. Finally, they recalled corrective messages and requested an appointment for the next visit. This began with a recall of the previous visit's observed deviations and the corrective actions needed.

The training lasted three weeks at the end of which mothers underwent an assessment, and the visits continued for 9 months, for message enhancement and support (Monte et al., 1997).

#### *Control group follow-up*

The control group did not receive any messages or training, but were visited by field workers in order to assist the laboratory staff in food sampling. Food samples were taken in control households at the same times as the intervention household's foods were sampled. Indeed field workers managed to schedule each intervention mother with her counterpart control mother. Information about the study's true objectives was not given to control mothers so that they

continued to prepare and handle their children's weaning foods as usual. However they benefited from allocations given to the intervention group – the hand washing kit and the amount of £2 on the day before each food preparation session.

#### *Food sampling and examination*

After the training, food samples were again collected in both intervention and control households and examined in the National Laboratory of Public Health. Three months later, a third round of food sample collection and examination was conducted to assess the persistence of behaviour change in the Intervention Group. For this purpose, the household visits were made without prior warning. At this stage, 15 intervention mothers were observed during food preparation and 15 were not observed, in order to assess the influence of the field workers' presence on the mothers' behaviour.

We concentrated on sampling foods for faecal coliform count at the moment of feeding children with cooled foods, after cooking and storage, and reheating if practised.

Food samples were collected aseptically by a specialist from the National Public Health Laboratory, assisted by a study field worker. Before collecting each sample, the temperature, pH and humidity of the food were measured. The samples were examined immediately, or kept in a refrigerator at 4 °C till their examination no more than 72 hours later.

To test for the presence of faecal coliforms, the Routine Method for Enumeration of Thermotolerant Coliforms (TTC) by Colony Count Technique at 44 °C was used (AFNOR, 1996). The standardized Violet Red Bile Lactose Agar (VRBL) method was used.

A 10 g aliquot of food was taken from the 200 g sampled in households, diluted in 90 ml of buffered peptone water and homogenised using a mixer bag. The solution (solution A) was allowed to settle for 15 min. 1 ml of the supernatant was transferred to a tube containing 9 ml of sterile solution and mixed (solution B). 1 ml of each solution was poured onto a separate sterile plate, and 15 ml of medium was added to each. Plate A thus contained 0.1 g, and plate B 0.01 g, of the original sample. The plate content was perfectly homogenised and left to solidify before incubation at 44 °C for 24 h. Violet colonies circled with a red zone with a diameter larger than 0.5 mm were counted. Only plates containing at least 15 and less than 150 characteristic colonies were considered.

The laboratory technicians were blinded to the mother's allocation to the intervention and control groups.

#### *Data analysis*

EpiDATA analysis 1.1 was used to calculate means and 95% confidence intervals (95% CI) of physical parameters.

TTC counts from the Intervention Group before and after the intervention were compared to assess the effectiveness of the intervention in reducing faecal bacteria in weaning foods. The Control Group TTC count was also used for comparison. No bacteriological standards are available for the two local meals studied. However, taking into account the hazardous environment in which the intervention occurred (with multiple faeco-oral transmission routes), and the capacity of our enumeration method for faecal coliform detection, we decided that 10 TTC/g was a reasonable target. This threshold (10 TTC/g) was selected to assess the performance of the intervention.

TTC colony counts were transformed logarithmically to calculate geometric means. Student's *t*-test, two-tailed type 3 was used to compare geometric means of bacterial counts, considering a difference significant if  $P < 0.05$ ; 95% confidence intervals were also calculated.

**Table 1**  
Characteristics of mothers in study.

Study group	Number reported (%)	
	Intervention	Control
Age		
15–24	12(40.0%)	9(30.0%)
24–34	15(50.0%)	16(53.3%)
35+	3(10.0%)	5(16.7%)
Education		
No schooling	15(50.0%)	19(63.3%)
Primary	10(33.3%)	9(30.0%)
Secondary & above	5(16.7%)	2(6.7%)
Occupation		
Housewife	14(46.7%)	15(50.0%)
Trader	7(23.3%)	8(26.7%)
Artisan	5(16.7%)	6(20.0%)
Civil servant	0	1(3.4%)
Other	4(13.3%)	0
Total	30(100%)	30(100%)

### Ethics

Informed consent was obtained from all participating households. The protocol for this study was approved by the Malian National Ethics and Life Sciences Committee and the Ethics Committee of the London School of Hygiene & Tropical Medicine.

### Results

Two selected mothers who reconsidered their participation were replaced by two others selected from the rest of the list of 120 volunteers. The characteristics of the final study population are shown in Table 1.

Mothers were very young in the two groups, 86% of them were under 35. Literacy was very low. About 50% of mothers were illiterate and were housewives, with no independent income; however some of them were active out of their household. One mother out of 60 was a civil servant.

### Assessment of mothers' compliance with training

It was considered that a message was complied with when the mother implemented accurately the corresponding corrective action to control faecal contamination at critical control points. For example, the following were considered inaccurate implementation: washing one hand or washing hands without soap or forgetting to wash hands at critical moments, during the process of food preparation and handling. A mother was asked to perform preparation and handling of one of the two foods selected. The field worker observed and took note of all deviations seen, but was instructed to make no comment. Table 2 displays the number of mothers in the intervention group who performed each message accurately, and the corresponding percentage.

Table 2 indicates that most of the mothers mastered the corrective actions after three weeks' training. Surprisingly, the reheating of leftovers (which is not a local habit) was completely adopted by mothers. However, hand washing scores remained less than the other measures. Nevertheless, their performance during food preparation confirmed the mothers' compliance with the messages.

The pH of the food samples ranged between 2.01 and 6.65, the values less than 7 meaning that foods were acid or slightly acid, due probably to the use of ingredients like monkey bread (baobab fruit) or lemon in *moni*, and lemon and vegetables in the fish soup.

### Results of microbiological examination

Figs. 1 and 2 summarise the results of microbiological examination of the samples of *moni* and fish soup, respectively. Table 3 shows the results in terms of geometric mean coliform counts. At baseline (Figs. 1(a) and 2(a)), most freshly-cooked weaning food was already faecally contaminated by the time it had cooled sufficiently for it to be served to a child. Only 26/60 (43%) samples of *moni*, and 9/60 (15%) of fish soup did not contain faecal coliforms at a detectable concentration of 10TTC/g or above. In 25/60 of *moni* samples and 41/60 of fish soup (total 66/120 or 55%) the concentration was greater than 100TTC/g.

After storage at room temperature, typically 36°C (range 28–46°C) for 3 to 6 h, the bacterial contamination was yet more common and more intense. Only 1/60 (2%) samples of stored *moni* and 2/60 (3%) of stored fish soup did not contain detectable faecal contamination, and in most samples – 49/60 and 54/60 of stored *moni* and fish soup respectively or 86% overall – the concentration was more than 100TTC/g. Yet more dangerously, in nearly one in six samples of stored food (6/60 of *moni*, 13/60 of fish soup), the concentration of faecal coliform bacteria exceeded 1000TTC/g.

The food produced by the mothers after their training showed a major improvement in microbiological quality (Figs. 1(b) and 2(b)). This is apparent from comparison either with the baseline data described above, or between the intervention and control groups. Comparing the data for different foods and different sampling points yields various *P*-values relative to the null hypothesis of no difference between Intervention and Control Groups before the intervention:

Moni		
-after cooking		<i>P</i> < 0.02
-after storage/reheating		<i>P</i> < 0.008
Fish soup		
-after cooking		<i>P</i> < 0.0001
-after storage/reheating		<i>P</i> < 0.002

Each of these comparisons is statistically significant, so that the entire effect of the intervention is still more so. The significance of the differences is also evident from the confidence intervals in Table 3.

From a position in which most samples were contaminated – many of them grossly, whether freshly cooked or stored – the mothers' implementation of their hygiene training achieved a standard at which no more than 5/30 (17%) samples of either food, whether freshly-cooked or reheated after storage, was faecally contaminated at a detectable level (>10TTC/g).

In contrast to the pattern at baseline, stored food in the intervention households was now no more likely than freshly-cooked food to be detectably contaminated with faecal bacteria; the practice of reheating stored food, together with the other hygiene measures introduced, had countered the effects of bacterial re-growth at the warm prevailing ambient temperatures.

### Intervention sustainability

In order to assess the sustainability of the behaviour change achieved, the intervention group mothers' capability to recall messages and the quality of the foods they prepared were assessed three months after the end of the intervention.

Field workers were provided with a check list of all messages. Each mother in the intervention group was asked to list all messages she learnt and implemented during the intervention. The field worker marked on the form messages recalled but neither asked or explained anything. Table 4 displays the number and the percentage of mothers who recalled accurately the hygiene messages they had been given three months previously.

Table 4 shows that the messages most recalled are hand washing before feeding a child and reheating of stored food, followed by

**Table 2**  
Messages seen to be implemented, after three weeks of training (30 intervention group mothers).

Occasion	Behaviour			
	No. of mothers observed performing the correct behaviour (%)			
	Use potable water (%)	Wash dishes (%)	Wash hands (%)	Reheat leftovers (%)
End of training	27 (90.0%)	26 (86.7%)	21 (70.0%)	30 (100%)
Moni sampling	30 (100%)	30 (100%)	30 (100%)	30 (100%)
Fish Soup sampling	30 (100%)	30 (100%)	29 (96.7%)	30 (100%)
Definition of correct practice	Only water from tap or bore hole	Use soap (can be local soap)	Deviation when one critical step missed	Until some time after appearance of vapour

**Table 3**  
Geometric mean counts of thermotolerant coliforms (TTC/g) in samples of weaning foods, *moni* and fish soup prepared by two groups of 30 volunteer mothers of young children. 95% CI are shown in brackets. Only the intervention group received a free three-week training course on hygienic production of weaning foods. Samples were collected (a) at baseline, (b) upon conclusion of the training, and (c) on an unannounced visit three months later.

		Geometric mean TTC/g (and 95% CI)		
		Baseline	After intervention	3 months later
Moni	Intervention group	After cooking	8 (3, 20)	2 (1, 5)
		After storage/reheating	181 (110, 298)	2 (2, 4)
	Control	After cooking	37 (15, 93)	312 (189, 516)
		After storage	312 (218, 448)	424 (265, 715)
Fish soup	Intervention group	After cooking	28 (12, 66)	2 (1, 3)
		After storage/reheating	226 (117, 437)	1 (1, 2)
	Control	After cooking	322 (256, 404)	370 (176, 777)
		After storage	715 (551, 927)	965 (671, 1387)

using potable water for domestic needs and washing dishes with soap. Hand washing after cleaning a child registered the lowest score.

Examination of the food samples collected three months after the training intervention, conditions showed no sign of deterioration; if anything, they had improved slightly. Only 5/60 (8%) of *moni* and 2/60 (3%) of fish soup samples were contaminated when freshly-cooked, and none of the 60 samples collected after reheating bore any detectable contamination at all. The prevalence and degree of contamination of samples from the 15 households which had been observed were no less than found in the other 15 intervention households (data not shown).

## Discussion

The information in Table 1 on the socio-economic and educational status of the mothers in the study agrees with other data on Mali (CPS/MS, 2007), and confirms that the study subjects are reasonably representative of the population as a whole. This has implications for the ultimate scalability of the intervention.

A major limitation of the study was imposed by the limited processing capacity of the National Public Health Laboratory, where the samples were examined. This constrained us to collect only three samples per household, and to examine only a single microbial indicator. Had the results of the study been less positive, that could have been a major problem. As it turned out, the involvement of the staff,

laboratories and funding of Mali's Ministry of Health was a major strength of the study as it helped to ensure local ownership of the results.

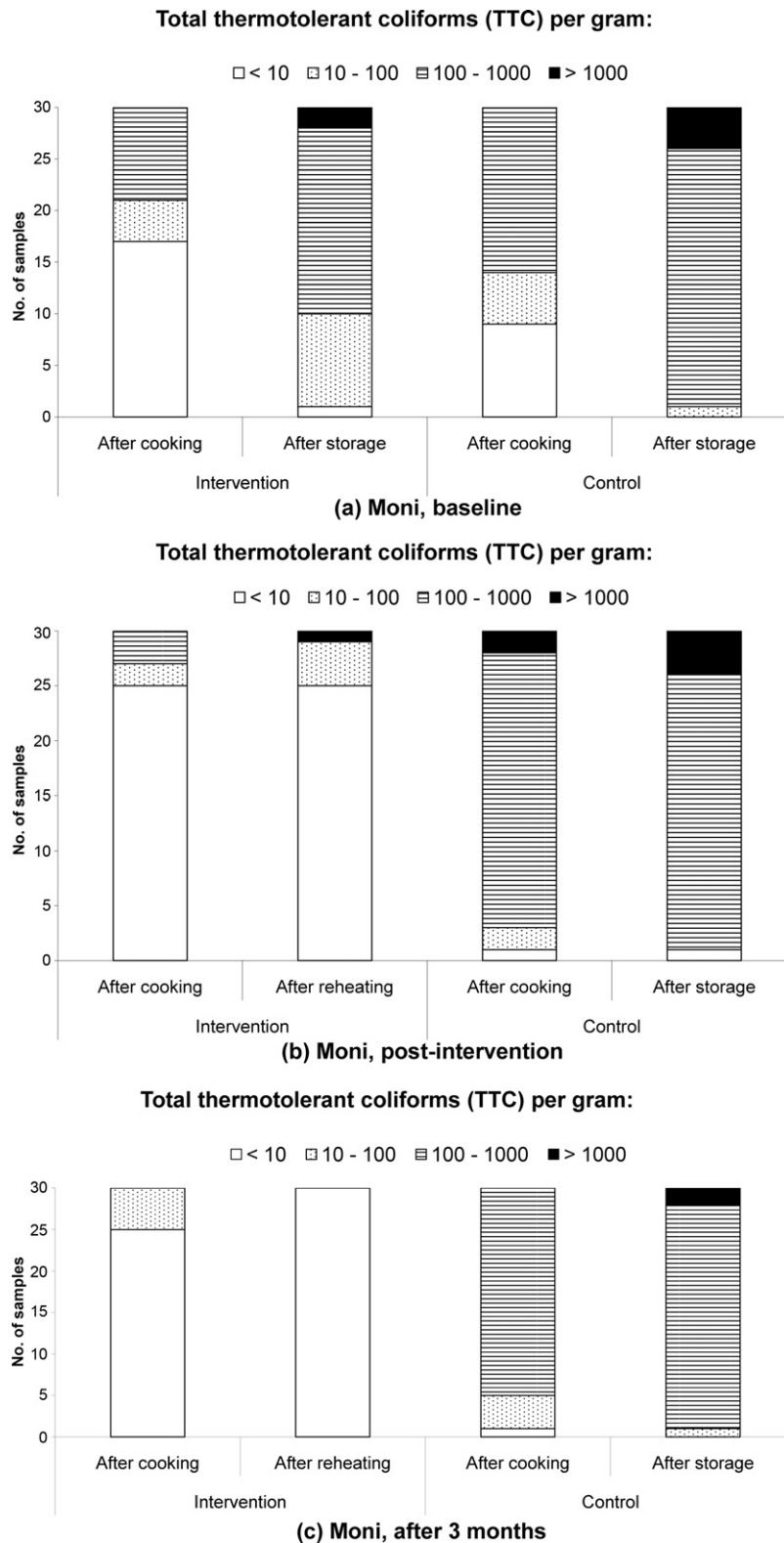
The levels of contamination found in the food at baseline and continuing in the foods of the control group may seem shockingly high but they are sadly typical of home-prepared foodstuffs consumed by young children in developing countries (Motarjemi et al., 1993). Baseline contamination levels ranged between 10 and more than 1000 TTC/g for two foods in two groups (Figs. 1(a) and 2(a)). These levels are similar to most of the findings of previous studies.

There was a significant difference in contamination levels between the two sampling points (or CCPs, to use the HACCP term): 'after cooking' and 'after storage' for the two foods. For both *moni* and fish soup, the CCP 'after storage' was more contaminated than that of after cooking ( $P < 0.0001$ ). This is consistent with the relation between microbial growth, temperature and time; indeed, at suitable temperatures, longer storage times are associated with higher microbial contamination. Motarjemi et al. (1993) have noted how bacterial pathogens in weaning food can multiply their numbers by many thousands during a few hours' storage at ambient temperature.

An evaluation of messages adopted after three weeks' training showed surprisingly that reheating, though it was not mothers' traditional behaviour, was the most understood and implemented (100%), and followed by potable water usage for domestic needs

**Table 4**  
Message recall by 30 intervention group mothers, three months after intervention (using check list).

Message	No. of mothers recalling the message (%) N = 30	Remarks
Use potable water for domestic needs	27 (90.0%)	Water from tap or borehole
Wash dishes with water and soap	27 (90.0%)	Local soap included
Wash both hands with running water and soap	19 (63.3%)	
	After latrines	
	After cleaning child	
	After touching contaminated material	Including raw food
	Before preparation	
	Before child feeding	
Reheat leftovers to boiling point	30 (100%)	Sometime after appearance of steam

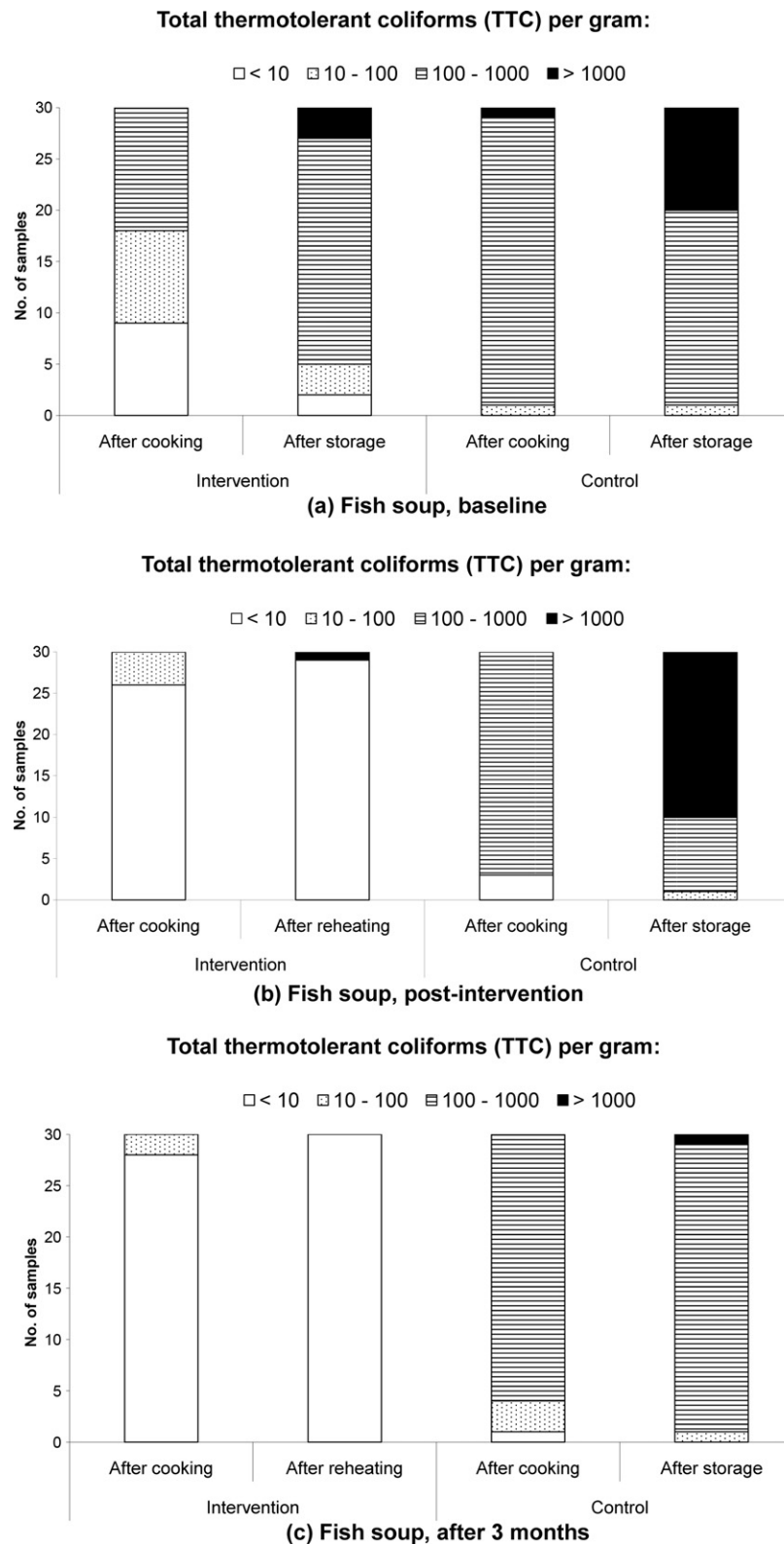


**Fig. 1.** Results of the microbiological examination; *moni*. Distribution of thermotolerant coliform counts in samples of weaning food *moni* collected from and prepared by two groups of 30 volunteer mothers of young children; the intervention group received a free three-week training course on hygienic production of weaning foods; the control group did not. Samples were collected (a) at baseline, (b) upon conclusion of the 3 week training course, and (c) on an unannounced visit three months later to test for sustainability of the hygiene measures inculcated by the intervention.

(90%) and washing of dishes (86.7%). Hand washing with potable water and soap at critical moments scored 70% (Table 2).

The possibility of ‘leakage’ of messages from the intervention to the control group could not be ruled out in advance.

However, the dramatic reduction in food contamination seen in the intervention households was not reflected in the control group (Figs. 1(b) and (c) and 2(b) and (c)). If it had been, such leakage would have diminished the size of the effect.



**Fig. 2.** Results of the microbiological examination; fish soup. Distribution of thermotolerant coliform counts in samples of fish soup collected from and prepared by two groups of 30 volunteer mothers of young children; the intervention group received a free three-week training course on hygienic production of weaning foods; the control group did not. Samples were collected (a) at baseline, (b) upon conclusion of the 3 week training course, and (c) on an unannounced visit three months later to test for sustainability of the hygiene measures inculcated by the intervention.

This study can be compared with a five-armed trial in Brazil (Monte et al., 1997) in which five messages (<sup>1</sup>hand washing before and after defined events, <sup>2</sup>boiling water for reconstituting of powdered milk, <sup>3</sup>feeding gruel by spoon rather than bottle-feeding, <sup>4</sup>not

storing gruels and milks, and, <sup>5</sup>all four together) were delivered respectively to five groups of 15 mothers, via a home visit to each mother, followed by three weekly follow-up visits. That resulted in the adoption and the advocacy of corresponding behaviours by

53% to 80% of mothers, and their being practised every time during a one-month period (Monte et al., 1997).

Our intervention was very effective in reducing the prevalence and intensity of faecal contamination – the latter by several orders of magnitude – and so meeting our quality standard (<10 TTC/g) in the vast majority of samples. It follows from this that (i) the intervention was efficacious in achieving behaviour change, and (ii) the specific behaviour changes were appropriate, and therefore the HACCP approach used to identify them (Touré et al., 2011) was also effective.

Possibly the most important change in the mothers' behaviour was the introduction of reheating of stored food. This was especially remarkable, for two reasons: (i) Prior to the intervention, observation showed that it was not normally practised, although the mothers' responses to questionnaires (data not shown) showed that they knew they 'ought' to do it. (ii) The cooking fuels normally used in Bamako are wood and charcoal, so that the job of setting, lighting and stoking a fire requires a non-trivial investment of effort and attention from a mother busy with childcare tasks.

The follow-up after three months does not prove that the changes in mothers' behaviour would be sustained after a full-scale intervention. Studies of some other behaviour changes, such as household water disinfection, have found their effects had all but disappeared in six months (Hunter, 2009). However, it does show that the relevant changes can be sustained by the target group, in spite of their poverty and workload.

The intervention described here is still far from being affordable and effective at scale by public health authorities or donor agencies in developing countries. The training was given in intensive one-to-one sessions over a full three-week period, by a small team of highly motivated hand-picked graduates, and followed up by fortnightly visits for the subsequent nine months. The trainees, though of modest socio-economic status, are volunteers from among a group already interested enough to have signed up for nutrition classes. Nevertheless, there is a serious lack of good trials with objective outcome measures providing evidence of the effectiveness of hygiene promotion (Curtis et al., 2011). This trial is one of efficacy, not effectiveness, but its positive result opens up the possibility of new types of intervention which hitherto had almost no evidence base at all.

What is now needed is pruning of the contact hours in the training, or their transfer to a cadre of community-based volunteers, or to mass media, so that it can be implemented on a wider scale as something nearer to an effectiveness trial.

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