

# Cost-effectiveness of a weaning food safety and hygiene programme in rural Gambia

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1 Title/subtitle: **The cost-effectiveness of a weaning-food safety and hygiene programme in rural**  
2 **Gambia**

3 Short title: Cost-effectiveness of a weaning-food safety and hygiene programme

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23

24 Abstract (250 words)

25 Objective

26 The main objective of the economic evaluation was to determine the cost-effectiveness of a weaning

27 food safety and hygiene programme in reducing rates of diarrhoea compared to the control in rural

28 Gambia.

29 Methods

30 The public health intervention, using critical control points and motivational drivers, was  
31 evaluated in a cluster randomised controlled trial at 6- and 32-month follow-up. An economic  
32 evaluation was undertaken alongside the RCT with data collected prospectively from a societal  
33 perspective. Decision-analytical modelling was undertaken to explore cost-effectiveness over  
34 a longer time period (4 years).

35 Results

36 Direct out of pocket healthcare expenditure for households due to diarrhoea was large. The  
37 intervention significantly reduced reported childhood diarrhoeal episodes after six months  
38 (incident risk ratio =0.40, 95%CI 0.33, 0.49) and two years after the intervention (incident risk  
39 ratio = 0.68, 95%CI 0.46, 1.02). The within trial analysis found that the intervention led to total  
40 savings of 8064 dalasi six months after the intervention, and 4224 dalasi two years after the  
41 intervention. Based on the model results, if the intervention is successful in maintaining the  
42 reduction in the risk of diarrhea, the ICER is US\$814 per DALY avoided over 4 years.  
43 According to the WHO CHOICE guideline, this is cost effective (below 3xGDP per capita).

44 Conclusions

45 This study suggests that there are substantial household costs associated with diarrhoeal  
46 episodes in children. The within trial analysis and model results suggest that the community-  
47 based approach to improving weaning food hygiene and safety is likely to be cost-effective  
48 compared to control.

49

50 Keywords

51 Cost-effectiveness, food safety, hygiene promotion

52

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54

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62

63

64

## 65 **Introduction**

66 Diarrhoeal diseases represent a major public health issue in lower and middle income countries (LMICs)  
67 and their reduction is vital to achieving substantial Development Goals for health (1, 2). The improved  
68 health and nutrition of infants and children is often not prioritized in current discourses on food systems,  
69 but there is an urgent requirement to ensure that such systems better respond to their needs (3). Amongst  
70 children aged under five, diarrhoea is the second highest cause of mortality (4-6) and frequent diarrhoea  
71 is associated with damage to the gut, further malnutrition and stunting (7, 8). The weaning period, when  
72 a child starts eating solid food, but does not fully eat the family meal (between 6 and 24 months), is  
73 associated with particularly high rates of diarrhoea in LMICs (9, 10). Food-safety and food-hygiene  
74 interventions aimed at preventing the consumption of contaminated food and liquids are seen as  
75 important in reducing rates of diarrhoea in children, but there is limited evidence about their  
76 effectiveness in terms of impacts on child health outcomes (11, 12). In addition, there is very little  
77 economic evidence about sanitation and hygiene programmes in general (13) or on the cost-  
78 effectiveness of particular types of intervention (14-16) .

79 Following formative research in the Gambia, a weaning-food safety and hygiene programme was  
80 developed (17). This was a community-based behaviour change intervention, with effectiveness  
81 investigated via a cluster randomised controlled trial (RCT) involving thirty villages (clusters) in The  
82 Gambia (18). The trial focused on the effects of this complex intervention on the following outcomes:  
83 mothers' weaning-food safety and hygiene behaviour (primary outcome), boiling drinking water,  
84 microbiological contamination in weaning-food and drinking water, rates of diarrhoea, diarrhoea  
85 admission, and respiratory infection. The main objective of the economic evaluation was to determine  
86 the cost-effectiveness of the weaning food safety and hygiene programme in reducing rates of diarrhoea  
87 compared to the control. The purpose of the economic evaluation was to inform current policy in this  
88 area, as the success of any intervention in supporting healthy weaning needs to be balanced against the  
89 resources required to achieve this outcome, and additional costs must be assessed in terms of any  
90 additional benefits that can be attributed to them (19).

91

## 92 **Methods**

93

94 *Study setting*

95 The site for the study was The Gambia’s Central River Region (CRR). CRR is Gambia’s poorest region  
96 and has the highest rates of diarrhoea (20). This was a 1:1 parallel cluster-RCT, and the unit of  
97 randomisation was a whole village. The inclusion criteria for a cluster was the whole of an average  
98 sized (200–450 population (21)) “Primary Health Care (PHC) village” with a village health  
99 worker/volunteer (VHW) and a traditional birth attendant (TBA). Villages within 5km of previously  
100 selected villages for the pilot were excluded to prevent contamination.

101

102 *The Intervention*

103 Full details of the intervention are published elsewhere (22). In brief, we developed a low intensity,  
104 community-based behaviour change intervention for weaning-food safety and hygiene (17). The co-  
105 designed community-level intervention had previously been evaluated in Nepal (23, 24) and was  
106 adapted via formative research in the Gambia (17, 18). The main intervention was delivered over 25-  
107 days (4 community campaign intervention team visits on days 1, 2, 17, 25) with female volunteers  
108 (MaaSupervisors) encouraging the mothers in-between campaign visits (17). The campaign visits, home  
109 visits and community meetings included dancing, songs and drama, and communities were encouraged  
110 to continue the behaviours and disseminate them among new mothers, with no incentive or contact from  
111 outside of their community. Five months later, a reminder visit was undertaken to remind villagers  
112 about the key behaviours. Control villages received a 1-day health education campaign from a Public  
113 Health Officer on water use in domestic vegetable gardening, including a community meeting.

114

115 *Resource use and cost definitions*

116 An economic evaluation was conducted alongside the RCT, with decision-analytic modelling  
117 undertaken to analyse longer term costs and outcomes. The overall aim was to analyse cost-  
118 effectiveness from a societal perspective, which included costs and benefits for the agencies responsible  
119 for setting up and delivering the intervention and for the households in the intervention villages,

120 compared to the control. Costs associated with developing and delivering the intervention were  
121 collected via trial reporting mechanisms. Costs to the household associated with episodes of childhood  
122 diarrhoea were captured via a questionnaire which included healthcare resource use, impacts on  
123 productivity and other costs. The questionnaire was delivered to participants in the trial during follow-  
124 up at 6 months and 36 months. We also included potential costs for the participants associated with the  
125 behaviour change promoted. As part of the intervention, households were encouraged to boil child's  
126 drinking water and reheat stored food. We included these costs in the analysis based on market prices.

127

#### 128 Data on effectiveness

129 Data on the prevalence of diarrhoea amongst children between 6 to 36 months old were collected at  
130 baseline (before the intervention), 6 and 32 months after the 25 day intervention period. "Primary Health  
131 Care (PHC) villages" (158) were grouped and randomized within 2 strata (north or south of the river  
132 and by quartiles of the village population) into 15 control and 15 treated villages. The survey sampling  
133 design was conducted in two stages. There were two strata, one with 86 villages (clusters) and another  
134 with 72 villages. For each stratum, 15 villages were randomly chosen and within the villages 20  
135 households were randomly chosen to conduct interviews and observations. The 15 villages from one of  
136 the strata were treated with the intervention while the other was the control group (22).

137

#### 138 Analysis of cost-effectiveness

139 We evaluated whether the intervention is cost-effective by extending from the framework proposed by  
140 Borghi et al (2002). Trial data were used to estimate the impact of the intervention on the prevalence of  
141 childhood diarrhoea<sup>1</sup> and the impact on healthcare resource use, productivity and wider household costs.  
142 Using the estimates from the trial, a Markov model was used to analyse the longer term cost-  
143 effectiveness of the intervention and this was compared with the WHO-CHOICE threshold (25, 26).

144

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<sup>1</sup> Childhood diarrhoea prevalence is calculated as the number of children who has diarrhoea in the past 7 days at the time of interview divided by total number of children interviewed. The calculations also include sampling weights, where we weigh each observation according to the different probabilities of being chosen to be interviewed due to the sampling procedure.

145 *Calculation of household savings per diarrhoeal incident*

146 We used Manjang et al. (2020) estimates of the treatment effect on childhood diarrhoea prevalence at  
147 household level (22). Manjang et al. (2020) estimated the treatment effect by using a mixed-effect  
148 Poisson model with a log-link, and adjusted for village-level stratification. The method allows for  
149 clustering within the level of randomisation (villages). We attached their point estimates of the effect  
150 of the treatment with the average cost of health treatment paid by households for one ill child to compute  
151 household savings per diarrhoeal incident.

152

153 *Calculation of household and agency costs*

154 Agency costs associated with delivering the intervention were collected prospectively using  
155 trial reporting processes. Costs associated with developing the intervention and training staff  
156 were assumed to be sunk costs which would not be borne by agencies and hence were excluded  
157 from the main analysis (see Appendix 2 for details of these costs). The costs included the  
158 resource use associated with delivering the intervention in a community setting. All costs were  
159 collected in Gambian Dalasi using trial processes. The costs were converted to US Dollars and  
160 inflated to 2017 prices (<https://www.exchange-rates.org/Rate/USD/GMD/6-21-2014>).

161 The intervention was comprised of several elements. The intervention involved travelling to  
162 villages and so transport costs were recorded and included. Technical equipment was necessary  
163 to deliver the intervention; this included a generator, a projector, a mobile printer, a tablet and  
164 a laptop. We assumed that this equipment could be re-used over a period of three years until  
165 they became outdated, and thus annuitised all these costs for three years (19). There were other  
166 re-usable resources used in the intervention (e.g. banners, fluorescent lights), again we assumed  
167 that these could be reused over a three-year period and annuitised costs accordingly. There  
168 were consumable resources associated with the intervention. This included soap, stationery and  
169 other items such as medals (given to participants).



170 Costs associated for participating in the intervention were calculated for households. We  
171 included the difference in means in expenditure for fuel between control and treatment groups,  
172 to take into account the impacts of the intervention on household fuel costs.

173

#### 174 *Decision-analytic modelling*

175 A decision-analytic model was used to examine the longer-term costs and benefits of the  
176 intervention. The appropriate model structure for this study was a Markov model, due to the  
177 cyclical nature of diarrhoea infections (27). The model had four states, healthy, mild diarrhoea,  
178 severe diarrhoea and death; possible transitions between states are shown in Figure 1. Two  
179 diarrhoeal states were included (mild and severe), because the severe state is associated with a  
180 higher probability of death, a higher disability weight and increased healthcare costs (28). In  
181 addition to this, hygiene interventions are expected to reduce the probability of severe diarrhoea  
182 relatively more than mild diarrhoea (29). The model was simplified and substantially adapted  
183 from an existing published model for an intervention to rotavirus (28).

184 The cycle length for the model was established as one month and the time horizon was 4 years  
185 (from age 12 months-60 months), in order to represent the full weaning period. A Simpson  
186 correction is applied to DALYs but not to costs, since it is assumed that costs are incurred at  
187 the beginning of the period; this makes very little difference since the cycle length is very short.

188 Within the model, the cohort all begins in the healthy state at age 12 months. Risk of developing  
189 diarrhoea declines in each cycle, reflecting higher incidence of diarrhoea at the beginning of  
190 the weaning period (20). Background mortality rate also declines over time as the cohort ages.

191 Trial data were used to estimate the intervention effects on the relative risk of diarrhea and  
192 costs associated with the intervention. Table 1 shows the other parameters used to populate the  
193 model, along with the sources used. It was assumed that the risk of death from mild diarrhoea  
194 is the same as the background mortality. The transition probability from severe diarrhoea to

195 death is simply background mortality, which declines over time, plus a time-invariant risk of  
196 death from diarrhoeal disease. The risk of diarrhoea-related death given a severe diarrhoeal  
197 episode, and the annual reductions in risk of death and background mortality were all chosen  
198 to calibrate the model to ensure that overall mortality, incidence of diarrhoea and diarrhoea  
199 mortality matched the Gambian 2010 national health survey data (20). Diarrhoeal episodes  
200 confer some temporary immunity from further diarrhoeal infections; an individual in either of  
201 the diarrhoea states has a 10% lower chance than a healthy individual of having diarrhoea in  
202 the following period, after which risk returns to normal (30). Costs and DALYs were  
203 discounted by 3%, following WHO recommendations (26).

204

#### 205 *Sensitivity analysis*

206 A probabilistic sensitivity analysis (PSA) was undertaken for the modelling element to examine  
207 the effects of the inherent uncertainty in the parameters (31). In a PSA all parameters are varied  
208 simultaneously, and multiple sets of values are sampled from defined probability distributions  
209 (32). This involved 1000 repeated random draws from the distributions to indicate how  
210 variation in the model parameters would affect the results and hence illustrate the decision  
211 uncertainty (33). Beta-distributions were used for binomial data and Gamma-distributions for  
212 costs (32).

213

## 214 **Results**

215

#### 216 *Intervention costs*

217 The intervention required a range of resources for agencies (Table 2). This included vehicle  
218 hire, a driver and fuel to travel to each of the 15 villages for the four days of the intervention,  
219 equipment such as a generator, a projector, a laptop, mobile printer, a tablet, fluorescent torch

220 lights, medals, soap and stationery. The intervention required input from a range of personnel.  
221 A Senior Public Health Officer (with an MPh in HIC) was responsible for the overall  
222 implementation of the intervention, supported by Junior Public Health Officers. Traditional  
223 Communicators were involved in delivering the culturally embedded drama and songs  
224 (performing arts). One MaaSupervisor was appointed in each village and was given a small  
225 amount of payment for this role. Combining the costs associated with wages and resources  
226 used for 15 villages, the intervention cost approximately USD 1000 per village (Table 2).  
227 There were also costs associated with the intervention for households. A significant difference  
228 was identified in fuel expenditure between treatment and control groups. The households in the  
229 treatment group spend 7.87 dalasi more than the households in the control group (see Table 3).  
230 This translates to approximately 4.6 dalasi used per diarrhoeal incident in the sample at endline.  
231 Soap costs were not included in the initial analysis as this was provided to participants as part  
232 of the intervention.

233

#### 234 *Costs associated with an episode of diarrhoea*

235 The findings from the survey demonstrated that both the direct cost and opportunity cost of a  
236 child having an episode of diarrhoea were substantial. Panel A in Table 4 shows that  
237 households sought help from various sources when a child had diarrhoea, with qualified health  
238 practitioner being the most common. Direct out of pocket healthcare expenditure for  
239 households was large (Panel B, Table 4) – in particular, medicine cost approximately 5% of  
240 the Gambia's GDP per capita per month<sup>2</sup>.

241 With only 76% of those surveyed reaching out for any help beyond friends and family (Panel  
242 A, Table 4), it is important to calculate opportunity costs (time off work etc.). Panel C in Table

---

<sup>2</sup> GDP per capita for the Gambia in 2015 was USD 458.97 (World Bank, 2018). This is approximately 22948 dalasi. We divide that figure by 12 to approximate monthly income (1912).

243 4 reveals that 43 percent of households whose child had diarrhoea had gave up an amount of  
244 time or income from work. It is notable that for those households, the mean number of days  
245 lost was four working days.

246  
247 *Effectiveness of the intervention*

248 The study found that the intervention significantly reduced reported childhood diarrhoeal  
249 episodes (defined as 3 watery stools in any day in the last 7 days as reported by mother) after  
250 six months (incident risk ratio =0.40, 95%CI 0.33, 0.49). This impact, albeit reduced in  
251 magnitude, persisted two years after the intervention (incident risk ratio = 0.68, 95%CI 0.46,  
252 1.02) (22).

253  
254 *Cost-effectiveness of the intervention*

255 Given the reduction in the prevalence of childhood diarrhoea in the intervention group, and the  
256 household costs associated with a child having an episode of diarrhoea, it was estimated that  
257 more than 47.26 dalasi was saved per diarrhoeal incident in a given one-week period in a treated  
258 village compared to a control village at six-month follow up and 24.76 dalasi at 36-month  
259 follow up (see Table 5). For the treatment group, it was estimated that 7571<sup>3</sup> dalasi  
260 (approximately equivalent to USD 151<sup>4</sup>) was saved six months after the intervention, and 3966  
261 dalasi (approximately equivalent to USD 79) saved two years after the intervention.

262 In addition to the direct healthcare costs, a diarrhoeal episode meant that households also  
263 reduced income due to the need to care for the ill child by 3.08 dalasi per diarrhoeal incident  
264 at 6-month follow-up and 1.61 dalasi per diarrhoeal incident at the 36 month follow-up.

265 Multiplying by the initial cases of diarrhoea in the treated villages at baseline, the opportunity

---

<sup>3</sup> Total savings from illness = Population illness in the treated villages at baseline x decrease of prevalence of illness x average cost. Approximately 160 households have a child who has experienced diarrhoea in the past 7 days at baseline (no. of households for treated villages times by average childhood diarrhoea prevalence at baseline)

<sup>4</sup> Used Dalasi-USD exchange rate: 0.02

266 cost saved for the intervention group is 493 dalasi six months after the intervention, and 258  
267 dalasi two years after the intervention. The total cost incurred by a household due to a child  
268 having diarrhoea is the sum of direct cost (healthcare costs) and income lost. The intervention  
269 led to total savings of 8064 dalasi six months after the intervention, and 4224 dalasi two years  
270 after the intervention.

271 The Markov model was used to estimate the overall cost-effectiveness of the intervention from  
272 a societal perspective over a 4 year time horizon. Based on the model results, if the intervention  
273 is successful in maintaining the reduction in the risk of diarrhoea (to the level found two years  
274 after the intervention), the ICER is US\$814 per DALY avoided, or US\$30,786 per diarrhoeal  
275 death averted. According to the WHO CHOICE guideline, this is cost effective, since it is  
276 substantially below 3xGDP per capita (26).

277 The probabilistic sensitivity analysis conducted (Figure 2) indicates that taking into account  
278 statistical uncertainty, that both the cost difference and the effect difference is likely to be  
279 statistically significant as there are an appreciable number of points clustered around the point  
280 estimate. This is confirmed by the cost-effectiveness acceptability curve (Figure 3) which  
281 shows that almost 80% of replications would be considered cost-effective as they cost less than  
282 three times average per capita income per DALY averted.

283

## 284 **Discussion**

285 The study found that the community-based weaning-food safety and hygiene programme  
286 intervention is likely to be cost-saving for households over the shorter and longer term, and  
287 cost-effective from a societal perspective. Substantial savings for households were  
288 demonstrated, associated with the reduction in healthcare costs due to the reduction in the  
289 prevalence of diarrhoea. In addition, savings were identified due to the reduced need to take  
290 time off work to care for an infected child. From a societal perspective, the intervention was

291 found to be very cost-effective according to the WHO CHOICE guidelines, as it was  
292 substantially below 3xGDP per capita.

293 The strength of this study is that detailed and comprehensive data on costs and resource use  
294 were collected which can inform similar interventions in this area and enable comparisons with  
295 other research findings. This is the first study to use survey data from The Gambia to estimate  
296 the costs associated with a child having an episode of diarrhoea, in terms of both healthcare  
297 costs and wider costs for the family. In addition, a societal perspective was adopted to ensure  
298 that costs and consequences were captured comprehensively (in line with recommendations).  
299 In addition to trial data, a Markov model was used to estimate longer term impacts.

300 There are a number of limitations associated with the study. The first is the short time horizon  
301 adopted for the modelling component, which almost certainly under-estimates the cost-  
302 effectiveness of the intervention, since the deaths averted occur in young children, who  
303 potentially have many years left to live. In addition, improved food safety and hygiene are  
304 associated with other health benefits, such as reduced respiratory infections, which have not  
305 been taken into account in this study. The trial data at 6 months found a statistically reduced  
306 imbalance of respiratory infection in the intervention arm. Additionally, while the focus is on  
307 weaning food and therefore on children between 12 months and 5 years old, better adherence  
308 to food hygiene protocol is likely to have ‘spillovers’ to other members of the household,  
309 including older children and adults as mothers were found to have significantly improved their  
310 food safety and hygiene practices for preparation of all family’s food. Again, this will result in  
311 the estimate of cost-effectiveness being an under-estimate of the true value (22). Other spill-  
312 over effects included improved self-efficacy on the part of the mothers and social cohesion and  
313 support amongst community members which are not accounted for here.

314 The simple model presented here does not accurately account for changes in diarrhoea risk  
315 resulting from accumulated immunity from previous infections (31); a much more complicated  
316 model structure would be required to take this fully into account (28).

317 The findings from this study contribute to wider evidence on the cost-effectiveness of  
318 interventions to improve food safety and hygiene. A recent study suggested that mass-media  
319 campaigns to promote healthy behaviours such as hygiene practices and taking ill children to  
320 a health facility was cost-effective. Similarly, an intervention to promote hygiene practices in  
321 Burkino Faso was found to be successful in reducing diarrhoeal disease incidence and cost-  
322 effective from a societal perspective. As there is very little economic evidence about sanitation  
323 and hygiene and none for household food safety and hygiene programmes (13), this study  
324 provides important information about the household costs associated with diarrhoeal episodes  
325 in children and the potential cost-effectiveness of a community-based approach to improving  
326 weaning food hygiene and safety.

327  
328  
329

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