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Cost-effectiveness of the community-based management of severe acute malnutrition by community health workers in southern Bangladesh

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This study assessed the cost-effectiveness of adding the community-based management of severe acute malnutrition (CMAM) to a community-based health and nutrition programme delivered by community health workers (CHWs) in southern Bangladesh. The cost-effectiveness of this model of treatment for severe acute malnutrition (SAM) was compared with the cost-effectiveness of the 'standard of care' for SAM (i.e. inpatient treatment), augmented with community surveillance by CHWs to detect cases, in a neighbouring area.

An activity-based cost model was used, and a societal perspective taken, to include all costs incurred in the programme by providers and participants for the management of SAM in both areas. Cost data were coupled with programme effectiveness data. The community-based strategy cost US$26 per disability-adjusted life year (DALY) averted, compared with US$1344 per DALY averted for inpatient treatment. The average cost to participant households for their child to recover from SAM in community treatment was one-sixth that of inpatient treatment. These results suggest that this model of treatment for SAM is highly cost-effective and that CHWs, given adequate supervision and training, can be employed effectively to expand access to treatment for SAM in Bangladesh.

Keywords Cost-effectiveness, activity-based costing, community health workers, severe acute malnutrition, community case management, community-based management of acute malnutrition, nutrition, Bangladesh, South Asia

KEY MESSAGES

- Community-based management of acute malnutrition (CMAM) delivered by community health workers (CHWs) is a cost-effective strategy compared with inpatient treatment, and compares well with the cost-effectiveness of other common child survival interventions.
- In this context inpatient treatment performed poorly in comparison with community treatment; even if performance was improved by 20% it would remain over eight times less cost-effective than the CMAM intervention.
- Households accessing CMAM through CHWs incurred considerably lower costs than those accessing inpatient treatment.

Introduction

Severe acute malnutrition (SAM) carries a high risk of death and requires therapeutic treatment for recovery (WHO 1999). Community-based management of acute malnutrition (CMAM) combines outpatient treatment of cases of SAM with no medical complications, including the absence of severe oedema and serious infection, with inpatient treatment to stabilize those cases that present with complications (Valid International 2006). This approach benefits households by reducing opportunity costs for caretakers (Ashworth 2006; Collins *et al*. 2006a; Collins *et al*. 2006b), and holds potential for introducing cost savings to health systems by reducing the number of cases of SAM needing intensive rehabilitation in an inpatient setting (Ashworth 2006; Collins *et al*. 2006a). There is concern in the international nutrition community, however, that the cost of a critical ingredient of CMAM programmes, ready-to-use therapeutic food (RUTF), is 'too' costly (Gupta *et al*. 2006; Golden 2007; Prasad 2009; Sachdev *et al*. 2010) when compared with inputs for other child survival programmes (Ashworth 2006; Horton *et al*. 2010). This has sparked ongoing debate about the affordability and cost-effectiveness of this treatment strategy (Horton *et al*. 2010). Despite the importance of these questions, relatively few studies have been conducted to ascertain CMAM's cost-effectiveness or to better understand how cost-effectiveness varies with programme structure and setting.

Cost-effectiveness of CMAM

The few reported cost analyses of CMAM suggest that it is cost-effective compared with alternative treatments for SAM. An Ethiopian study found CMAM to be more than twice as cost-effective as an inpatient therapeutic feeding centre, with costs per recovered case of US$145 vs US$320, respectively (Tekeste 2007). In Bangladesh, home treatment of SAM was found to be five times more cost-effective than inpatient treatment, at US$29 per child recovered compared with US$156 for inpatient care. This cost was low because no food was provided by the programme: these costs instead became the responsibility of beneficiary households. Although the costs incurred by households were highest for home care in this study, parents preferred this option because it allowed them the convenience of staying at home (Ashworth and Khanum 1997).

In Zambia, CMAM was found to cost an average of US$203 per child, US$1760 per life saved and US$53 per disability-adjusted life year (DALY) averted (Bachmann 2009). In Malawi, the incremental cost-effectiveness of adding CMAM to existing health services was US$42 per DALY averted, and US$1365 per life saved (Wilford *et al*. 2011). These results suggest that CMAM is highly cost-effective (Jha *et al*. 1998; Commission on Macroeconomics and Health 2001).

A recent World Bank report on addressing malnutrition at scale included treatment of SAM with ready-to-use therapeutic food (RUTF) as one of a number of proven interventions (Horton *et al*. 2010). Notwithstanding its effectiveness at saving the lives of children at high risk of death (Collins *et al*. 2006a), CMAM, at US$200 per child treated, was found to be the most expensive strategy per child but not per DALY averted relative to other existing nutrition strategies, underscoring concerns about its costs. Further, weak delivery capacities were cited as a barrier to scale-up of this approach in the under-resourced countries where SAM predominates (Horton *et al*. 2010).

Justification for the study

Given the persistent concern about the costs of CMAM, there is a need for a better understanding of these costs, particularly those of the newer CMAM delivery models. This analysis included costs to participating households, thereby adopting a societal perspective as is recommended by the Panel on Cost-Effectiveness in Health and Medicine of the US Public Health Service (Russell *et al*. 1996), and used activity-based costing with an ingredients approach as is recommended by the World Health Organization (Tan-Torres Edejer *et al*. 2003) to assess the cost-effectiveness of a CMAM model in southern Bangladesh, with treatment delivered by community health workers (CHWs). This study aimed to contribute evidence to claims that opportunity costs are lower for caretakers participating in CMAM than in inpatient treatment of SAM (Ashworth 2006; Collins *et al*. 2006a; Collins *et al*. 2006b). Further, this is the first study that has examined the cost-effectiveness of delivering CMAM protocols outside of health facilities, with CHWs providing the full spectrum of identification and treatment of SAM with no complications. Most CMAM programmes to date have been delivered by workers at primary and secondary level health care facilities. Currently in Bangladesh, the treatment of SAM remains based in inpatient care (IPHN *et al*. 2008). Cost-effectiveness data for complementary interventions such as CMAM, that hold potential for improving coverage and outcomes associated with this treatment, are needed to help the Government of Bangladesh make decisions about national strategies for addressing this common condition.

The first objective of this analysis was to compare the cost-effectiveness of CMAM delivered by CHWs relative to inpatient treatment of SAM. The second objective was to provide a disaggregated cost analysis of the integration of SAM treatment into an existing community-based health and nutrition programme in Bangladesh.

Methods

Description of the intervention

This study was conducted within a Save the Children (US) (SCUS) health and nutrition programme that employed a cadre of CHWs to deliver preventive and curative care to children in underserved areas of southern Bangladesh. Each worker was paid a monthly stipend of 800 Taka (US$11.80). CHWs counselled communities on health, nutrition and sanitation, and used treatment algorithms to deliver community case management of basic childhood illness including diarrhoea and acute respiratory infection.

Within the programme area, Bhola District was selected to be the study site as it had the highest prevalence of acute malnutrition among children. Two neighbouring upazilas within Bhola District were matched on the basis of their similar demographic and socio-economic characteristics and health infrastructure; these served as the sites in which to conduct the comparative analysis of the community and inpatient management of SAM.

In the intervention upazila, all CHWs received training, with monthly refreshers, and ongoing supervisory support to implement the community case management of SAM (called 'community treatment' throughout this analysis and based on the CMAM model of care), for children 6–36 months of age. Children were screened at monthly Growth Monitoring and Promotion (GMP) sessions and household visits. Cases of SAM with medical complications (five children) were referred to the Upazila Health Complex (UHC), the equivalent of a general hospital, for a few days of stabilization care (the costs of which were included in the analysis) before returning home for community treatment (Valid International 2006). Cases of SAM without medical complications received weekly follow-up visits at home by the CHW. For these children nutritional treatment included a weekly ration of RUTF (Plumpy'nut®, Nutriset, Malaunay, France) with equivalent nutritional value to Formula 100 therapeutic milk, providing 175–200 kcal/kg/day and 4–5 g protein/kg/day, and medical treatment that included a single oral dose of folic acid (5 mg) and the broad spectrum antibiotic Cotrimoxazole (Trimethoprim 5 mg/kg and Sulphamethoxazole 25 mg/kg) given orally by caretakers twice a day for 5 days. CHWs monitored children using weight and mid-upper arm circumference (MUAC) measurements until the child recovered (as defined by a weight gain of 15% of admission weight, a MUAC over 110 mm and/or loss of oedema). Where there was no record of the child receiving anthelminthics and/or Vitamin A in the previous 6 months, these treatments were prescribed according to national protocol.

Facility-based inpatient treatment of SAM at the UHC is the existing standard of care in Bangladesh (here referred to as 'inpatient treatment'), and for this study its effectiveness was compared with that of community treatment (Table 2). Given the low coverage traditionally achieved by inpatient facilities (Collins *et al*. 2006a; Sadler *et al*. 2007), in order to compare the effectiveness of both treatment models in managing SAM, it was considered necessary to ensure that there existed equivalent levels of case-finding in the intervention and comparison area. To this end, CHWs in the comparison upazila were trained to identify children with SAM and refer them to the UHC while continuing to provide counselling, and treatment for acute respiratory infection and diarrhoea. Programme activities in the comparison upazila therefore included inpatient treatment along with community-based surveillance by CHWs for case identification, referral and follow-up. Table 2 presents the number of participants in each study group. The UHC was provided with inputs including training based on World Health Organization (WHO) and National Guidelines (Ashworth *et al*. 2003; IPHN et al. 2008), supervisory and staffing support, and the materials and supplies necessary for delivery of inpatient treatment. SCUS programme staff monitored UHC service delivery over the course of the study. After being referred to the UHC, caretakers of children with SAM either chose to stay in treatment until their children recovered, or they left the facility and returned home before the child completed treatment (referred to as 'defaulting'). Other caretakers either refused referral to the UHC and stayed in the community or were referred but not admitted, due to limited beds and staffing. These latter groups, whose children did not receive inpatient treatment, accessed outpatient care from other sources such as village doctors and pharmacists. Additionally, CHWs continued to provide routine counselling and treatment of acute respiratory infection and diarrhoea, with additional household monitoring visits and subsequent referrals where necessary. All this support is referred to as 'other outpatient care' in this analysis.

Ethical approval was obtained for this study from the Institutional Review Board of Tufts University, USA and from the Bangladesh Medical Research Council (BMRC). Approval was also obtained from the Director General for Health Services (DGHS) in Dhaka, Bangladesh.

Analytical strategy

This analysis aimed to compare the total costs of community and inpatient treatment of SAM including community-based case-finding by CHWs. An activity-based cost analysis was used, with the sum of the estimates for all component activities designed to capture total programme costs. Costs included were intended to reflect the full range of resources required by households and care providers to initiate and sustain community and inpatient treatment of SAM, along with active case-finding, treatment, referral and follow-up by CHWS, during the first 'start-up' year. Costs for the comparison upazila include costs for inpatient treatment combined with community-based outreach for case identification and follow-up, along with costs incurred by households in accessing all care for SAM. Further, this analysis focused on the total incremental costs of adding the management of SAM to the existing programme, considering only those activities or proportions of activities specifically relevant to this objective. All costs were expressed in local amounts where possible, and converted from Bangladesh Taka (BDT) to US Dollars using the April 2010 exchange rate (1 US$=67.941 BDT) (OANDA 2010).

To estimate programme costs, a micro-costing approach was applied wherein all activities were broken down into their component 'ingredients', with costs estimated for each ingredient (Tan-Torres Edejer *et al*. 2003). The societal perspective was taken, with data collected on household costs incurred for participation in both community and inpatient treatment. This approach captured all resources used to treat SAM, regardless of who incurred them (Weinstein *et al*. 1996; Russell *et al*. 1999). Programme staff were consulted to create a list of cost centres to which all programme costs were allocated. Supervisory costs were aggregated rather than allocated to activities to facilitate their analysis as a proportion of overall costs. Cost centres were comprehensive and mutually exclusive, providing a total cost for activities related to community and inpatient treatment of SAM without double counting any of the resources used to implement the programme. Results were analysed as cost-effectiveness ratios in terms of costs (in 2010 US$) per child treated and recovered, and per DALY averted. A sampling-based sensitivity analysis determined the relative effect of different inputs on the calculated number of DALYs averted in community and inpatient treatment, and produced credible intervals for cost-effectiveness outcomes. An improved scenario was modelled for inpatient treatment outcomes to determine the potential for improved cost-effectiveness.

Cost centres were analysed as percentage of overall costs for each area.

Table 1 describes cost centres and their data sources.

Cost data were coupled with outcome (effectiveness) data collected during programme monitoring and presented in Table 2 (Sadler *et al*. 2011). A comparison of clinical characteristics between children admitted to community treatment, and those referred and admitted to inpatient treatment is presented in Table 3.

DALYs are a standard metric for disease outcomes combining the years of life lost (YLL) due to premature mortality and the years lived with disability (YLD) (Murray 1994). Averting DALYs represents an intervention's ability to avoid or prevent negative health outcomes such as death and lasting disability. Calculating cost per DALY averted facilitates comparison between health interventions. DALYs attributable to death and disability due to SAM were calculated using the standard formulas (Murray and Lopez 1996; Fox-Rushby and Hanson 2001) and differing assumptions for calculation of YLL and YLD as described in Table 4.

Since treating SAM averts mortality, this DALY calculation accounts for the probable number of lives that would have been lost in 1 year without treatment. To do this it includes previously reported estimates of mortality of untreated SAM at different levels of MUAC. A value appropriate for the median admission MUAC (106.7 mm) was calculated using linear interpolation and published data with cohorts of patients the same age as those in this programme, and located in countries with limited access to health services, including Bangladesh (Briend and Zimicki 1986; Briend *et al*. 1987), Malawi (Pelletier *et al*. 1994) and Uganda (Vella *et al*. 1994). Taking into account a baseline mortality risk of 1/10 000/day, the expected mortality rate was estimated as 207 deaths per 1000 cases per year. That is, 20.7% of the cohort of SAM cases would be expected to have died within a mean of 6 months of admission, or onset of a SAM episode. (See Supplementary Materials for further detail regarding the mortality estimate used in this analysis and discussion of methodological issues surrounding estimation of mortality attributable to untreated SAM.)

The expected mortality rate was multiplied by the number of cases treated successfully, or recovered from SAM, to get the total deaths averted, and used to weight the YLL and YLD components of the DALY estimate. YLD was calculated for all treated children. YLL and YLD were summed to get the final DALY estimate.

Data collection

Cost data were collected in March and April 2010. Provider costs were collected via semi-structured key informant interviews with field staff, programme officials and administrative staff at SCUS, clinical and finance staff at the UHC, and review of key programme, administrative and financial documents (Table 1). Time allocation interviews were conducted with programme and clinical staff to estimate the personnel resources devoted to implementing, monitoring and overseeing treatment of children with SAM. Estimates from time allocation interviews were triangulated among staff of the same level, and with supervisory staff where possible. For those staff with

Table 1 Description of cost centres and data sources

Cost centre	Description	Data sources
1. Monitoring	Personnel and transportation costs incurred while monitoring and supervising CHWs during community case management of SAM.	Time allocation interviews with programme and supervisory staff. Review of key programme, administrative and financial documents.
2. Training	Technical instruction in SAM management for community and inpatient staff, both initial and refresher trainings. Includes salary, per diems, transport and supplies.	Key informant interviews with administrative and programme staff at SCUS. Review of training plans and budgets.
3. Supervision	Personnel and overhead costs for programme supervision at all levels of the programme. Proportion of time at monthly co-ordination meetings.	Key informant interviews with administrative and accounting staff at SCUS. Time allocation interviews with programme and supervisory staff. Review of key programme, administrative and financial documents.
4. Growth Monitoring and Promotion (GMP) sessions	Shadow costs for CHW wage and site rental for additional time at GMP session attributable to identifying and treating cases of SAM.	Key informant interviews with administrative and programme staff at SCUS. Time allocation interviews and surveys with CHWs.
5. Household visits	CHW time spent visiting households of children with SAM, and all printed materials and supplies used in case management of SAM.	Key informant interviews with administrative and programme staff at SCUS. Time allocation interviews and surveys with CHWs.
6. Curative care	All curative care for SAM, including medicines and therapeutic foods (and its transportation and storage) for community management, and equipment, medicines, food, bed and personnel costs at inpatient facility.	Key informant interviews with programme, administrative and accounting staff at SCUS and the UHC. Time allocation interviews with clinical staff. Review of key programme, administrative and financial documents. Online drug price indicator (Management Sciences for Health 2010).
7. Household costs	Value of caretaker's resources spent and extra time feeding their child with SAM or accessing care for SAM from CHW, UHC or elsewhere, including treatment-seeking, medicines and additional food purchased for child.	Focus group discussions with caretakers of children with SAM. Programme monitoring database.

Notes: CHW = community health worker; UHC = Upazila Health Complex; SAM = severe acute malnutrition; SCUS = Save the Children (US).

whom an interview was not possible or practical, time allocation estimates were taken from grant budgeting staff. All relevant key informants were identified both at SCUS and the UHC, with a total of 32 interviews conducted.

Participant costs were collected using semi-structured guides for focus group discussions (FGDs). Three guides were designed and piloted, one each for caretakers in three groups: community treatment, inpatient treatment and other outpatient care. Caretakers were selected from a range of unions (the lowest tier of regional administration) within the study area, with 28 participants in community treatment (four FGDs), 21 in inpatient treatment (four FGDs) and 25 in other outpatient care (three FGDs). Point estimates for direct costs represent the median value for each cost item from each group. Point estimates for indirect costs represent the median time allocated for various activities multiplied by the hourly shadow wage (see below). Medians were used so that extreme values would not distort the point estimate from what might be considered typical. Participants were assumed to have a demographic profile similar to the average woman in Bhola district, characterized by low income and education levels.

Costs included were those incurred from diagnosis through recovery from SAM, covering slightly different time periods for each group. Community treatment discussions covered the costs incurred during the CHWs' treatment of SAM. Inpatient treatment discussions covered the time spent from CHW's diagnosis of SAM until the end of the treatment episode (i.e. discharge as recovered, defaulted, non-response or death), including time spent at the UHC in addition to any extra food, medicine and time costs incurred after default. Other outpatient care discussions included costs incurred since diagnosis on extra food and medicines for the child, transportation while seeking care for child, and time spent feeding child, meeting with CHW or seeking treatment for the child.

Table 2 Effectiveness data from community and inpatient SAM treatment[a]

Outcome	Community treatment $N=724$ % (n)	Inpatient treatment $N=633$[b] % (n)
Recovered	91.9 (665)	1.4 (9)
Defaulted	7.5 (54)	7.9 (50)
Non-responder	0.6 (4)	0.3 (2)
Refused referral	–	52.9 (335)
Non-admitted	–	37.4 (237)
Died	0.1 (1)	0[c]

Notes: [a]Nine children with severe acute malnutrition (SAM) in the intervention area and seven children in the comparison area were excluded from the analysis because they required special treatment. Exclusion criteria were: age less than 6 months; weighing less than 4 kg on admission; or having severe cerebral palsy, cleft palate or obvious dysmorphic features suggestive of an underlying syndrome.

[b]This refers to the total number of children identified with SAM in the comparison area, whether or not they received inpatient treatment.

[c]The long-term mortality rate in children not under treatment is unknown.

Costing assumptions

A shadow wage for CHWs and caretakers was valued at the wage rate for women in public works: 100 Taka (US$1.47) for a 5-hour workday, or 20 Taka (US$0.29) per hour. Rental rates for buildings and equipment were used to estimate capital costs (Creese and Parker 1994). Capital depreciation was estimated for cars and computers. Costs were not adjusted for inflation as they covered less than one year. (See Supplementary Materials for further details on cost calculations and assumptions.)

Table 3 Clinical characteristics of children presenting for treatment in the intervention and comparison areas

Characteristic		Intervention: Admitted to community treatment		Comparison: Referred to inpatient treatment		Comparison: Admitted to inpatient treatment		Referred[c]	Admitted[d]
		n	value	n	value	n	value	P-value[e]	P-value[e]
Age	Age (months)[a]	722	16 (11, 23)	633	16 (11, 22)	61	13 (11, 20)*	0.1732	0.0357
Admission criteria	MUAC only	711	98.2%	630	99.5%*	61	100.0%	0.0244	0.2913
	Oedema only	6	0.8%	0	0.0%*	0	0.0%	0.0217	0.4754
	MUAC and oedema	7	1.0%	3	0.5%	0	0.0%	0.2895	0.4405
Severity of disease	MUAC (mm)[a]	724	108 (106, 108)	633	108 (106, 108)	61	104 (94, 106)***	0.3376	<0.0001
	Pneumonia	24	3.3%	6	1.0%**	6	9.8%*	0.0031	0.0107
	Diarrhoea	12	1.7%	1	0.2%**	1	1.6%	0.0047	0.9915
	Diarrhoea with dehydration	1	0.1%	1	0.2%	1	4.4%***	0.4150	0.0001
	Any complication[b]	87	12.0%	56	8.9%	14	23.0%*	0.0580	0.0143

Notes: [a]Median and interquartile range (IQR).

[b]Presenting with one or more of pneumonia, diarrhoea, diarrhoea with dehydration, hypothermia, and fever.

[c]Comparison between children admitted to community treatment and children *referred* to inpatient treatment.

[d]Comparison between children admitted to community treatment and children *admitted* to inpatient treatment.

[e]P-value for Wilcoxon test (age and MUAC) or chi-square test for equality of proportions (all other variables).

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

MUAC = mid-upper arm circumference.

Table 4 DALY model input parameter values and distributions

Parameter	Units	Baseline estimate	Distribution[a]	Parameter source and notes
Proportion of cases female	n.a.	0.623		
Proportion recovered (community treatment)	n.a.	0.919	Binomial ($n = NT^c$, $P = BE^b$)	
Proportion recovered (inpatient treatment)	n.a.	0.014		*Source*: Programme data
Number treated (community treatment)	cases	724	Fixed	
Number treated (inpatient treatment)	cases	633		
Degree of disability for death (YLL)	n.a.	1		*Source*: WHO (2004)
Degree of disability for wasting (YLD)	n.a.	0.053	Fixed	
Life expectancy (males) (YLL)	years	66.0		*Source*: WHO (2009), Bangladesh estimates for age group 1–4 years
Life expectancy (females) (YLL)	years	67.2		
Age at start of episode (YLD)	months	19.4	Gamma ($k = BE^b$, $\theta = 1$)	Mean: age at admission
Age at death (YLL)	months	25.4		Mean: 6 months after admission
Duration of SAM episode (YLD)	months	6		Untreated cases
Age-weighting modulation factor	n.a.	1		
Age weight	n.a.	0.04	Fixed	*Source*: Fox-Rushby and Hanson (2001)
Constant	n.a.	0.1658		
Discount rate	n.a.	0.03		
Expected deaths within one year	deaths	207/1000/year	Poisson ($\lambda = 0.207 \times PR^d \times NT^c$)	*Sources*: Briend and Zimicki (1986), Briend *et al*. (1987), Pelletier *et al*. (1994), Vella *et al*. (1994)

Notes: [a]Probability distribution functions used to produce credible intervals around certain model parameters.
[b]BE = Baseline estimate. Source is listed in notes column.
[c]NT = Number treated.
[d]PR = Proportion recovered.

Data analysis and sensitivity analyses

Cost data were entered and cleaned using Microsoft Excel software (Microsoft 2010). Errors were modelled for each cost centre using the authors' estimations of uncertainty around the data sources as shown in Table 5, assuming normal errors to calculate a 95% credible interval on the baseline estimates for each cost centre total in Table 6. Total costs for each input in Table 6 were divided by relevant units of analysis to estimate unit costs per input (i.e. cost per child, cost per household, etc.).

Programme effectiveness data were analysed using Stata statistical software version 11.0 (StataCorp 2009). Significance tests were conducted to detect any differences in clinical characteristics between children admitted to community treatment and those children referred and admitted to inpatient treatment. Purpose-written scripts for the R Language for Data Analysis and Graphics were used to calculate DALYs and cost-effectiveness ratios, and to conduct sensitivity analyses (Ihaka and Gentleman 1996). Uncertainty in the data was modelled with a sampling-based sensitivity analysis, using probability distributions of the model parameters (see Table 4) generated with Monte Carlo simulations using 1 million replicates per analysis and assuming all errors to be uncorrelated (Efron and Gong 1983; Briggs *et al*. 1997). A one-way sensitivity analysis was conducted using an alternative mortality rate, in order to gauge the sensitivity of cost-effectiveness outcomes to this model parameter.

Cost-effectiveness ratios for several outcomes of interest were calculated by dividing total programme costs by outcome measures. Estimates of DALYs averted were calculated separately for community and inpatient treatment compared with a no treatment alternative (assuming costs to be zero) with the same expected mortality rate (see Table 4) for all cases of untreated SAM within 6 months of start of episode.

An 'improved' scenario was modelled for inpatient treatment outcomes by applying a modest improvement of 20% to the coverage, recovery and default rates observed at facility level in the comparison upazila.

Results

Clinical characteristics comparison

Table 3 presents a comparison of clinical characteristics showing that, compared with children receiving community treatment, those receiving inpatient treatment in the comparison group were younger, with lower MUAC and higher levels of complications such as pneumonia and diarrhoea with dehydration at start of treatment.

Cost centres

Table 6 presents costs for each cost centre.

Table 5 Cost data error estimates by cost centre (US$)

Cost centre	Baseline estimate	Distribution	Error estimates
Community treatment			
Monitoring	$16 075		20%
Training	$14 423		5%
Supervision	$47 721		20%
GMP sessions	$3 043		10%
Household visits	$1 981		10%
Curative care	$30 109		5%
Household costs	$6 345	$Normal\ \mu = BE,$	40%
Inpatient treatment		$\sigma = \frac{error}{1.96} \times BE$	
Monitoring	$7 685		20%
Training	$9 929		5%
Supervision	$24 046		20%
GMP sessions	$1 803		10%
Household visits	$3 522		10%
Curative care	$2 505		5%
Household costs	$32 834		40%

Notes: All costs are in US$; BE = baseline estimate. More detail on costs is presented in Table 6. GMP = Growth Monitoring and Promotion.

Cost-effectiveness outcomes

Table 7 summarizes cost-effectiveness outcomes for community and inpatient treatment, including an 'improved' scenario for inpatient treatment.

Examination of two-way input–output scatter plots revealed that the estimate of DALYs averted was only marginally sensitive to all input variables apart from the projected number of deaths in the patient cohort, to which it was highly sensitive. This variable accounted for almost all variation in the DALY estimates. A one-way sensitivity analysis was used to examine the variation in outcomes when using different mortality estimates (analysis not shown). Substituting one-half the expected mortality rate from the literature (10%) resulted in a cost per DALY averted of US$53 [95% confidence interval (CI) = US$41–70] and a cost per death averted of US$1803 (95% CI = US$1414–2378).

Cost centre comparison

Figure 1 presents the proportion of costs attributed to each cost centre for both community and inpatient treatment.

Two costs predominated in community treatment: management costs (combining the monitoring and supervision cost centres) and curative care. RUTF and related storage and transport represent nearly all 'curative care' costs in community treatment (Table 6), and constitute 24% of total costs. Management costs, including salaries and overheads, comprised over half of total programme costs at 53%. These activities were conducted by SCUS staff in both areas, resulting in similar costs for inpatient treatment (39% of total). Curative care for inpatient treatment, including therapeutic milks, hospital overhead and clinical personnel time, was a significantly smaller proportion of total costs (3%) than for community treatment (25%). This is primarily because few children were treated at the UHC. Costs representing actual service provision by CHWs (combining cost centres for household visits and Growth Monitoring and Promotion sessions) made up only 5–6% of total costs in both areas.

In the comparison area, costs incurred by households for treating cases of SAM comprised the largest proportion of total costs, at 40% compared with 5% for community treatment, supporting claims that opportunity costs are lower for caretakers participating in CMAM (Collins *et al*. 2006a; Collins *et al*. 2006b). Household cost estimates, collected in community discussions, are further detailed in Table 8. This qualitative data, while not intended to be representative of all participating households, enables a basic comparison of the difference in costs among groups. Costs for beneficiaries in community treatment were lower compared with inpatient treatment or outpatient care for medicines (median = US$0.44 vs US$8.32 and US$4.42, respectively) and food (median = US$0 vs US$1.47 and US$1.77 per week, respectively), as well as transportation and opportunity costs of time. The main resource expenditure for households receiving community treatment was the time required for programme participation, including interaction with the CHW and following her advice on responsive feeding.

Discussion

Cost-effectiveness

Community treatment of SAM by CHWs in Bhola cost US$26 (95% CI = US$21–31) per DALY averted compared with no treatment, and US$869 (95% CI = US$723–1059) per death averted. Bangladesh's 2009 per capita gross domestic product (GDP) was US$551 (World Bank 2011), suggesting this intervention to be highly cost-effective according to the WHO's GDP per capita threshold for cost per DALY averted (Commission on Macroeconomics and Health 2001). These results (Table 9) are within the same range as the two other published costs per DALY averted for community treatment of SAM: US$42 in Malawi (Wilford *et al*. 2011) and US$53 in Zambia (Bachmann 2009). Further, these results suggest community treatment of SAM to have cost-effectiveness outcomes comparable with other basic health interventions in developing countries, such as childhood immunization (US$8 per DALY averted), insecticide-treated bed nets (US$19–85 per DALY averted) and treatment for infectious tuberculosis (US$5–10 per DALY averted) (Jamison *et al*. 2006), and commensurate with the most cost-effective health interventions identified by a World Bank study (US$50 or less per life year saved) (Jha *et al*. 1998).

Results from this study echo the findings of other analyses showing community treatment of SAM to be more cost-effective than inpatient treatment. Previous studies found inpatient treatment to be from two to five times as costly as community treatment to recover a child from SAM (Ashworth and Khanum 1997; Tekeste 2007). Costs per child recovered in Bhola were similar to those in Ethiopia (US$180 and US$145, respectively) (Tekeste 2007). Further, costs per child treated by CHWs at US$165 were similar to the costs of a programme based out of primary health care facilities in Zambia at US$203 (Bachmann 2009), suggesting that costs may not differ strongly between African and South Asian settings or among various CMAM delivery models. In Bangladesh, Ashworth and Khanum (1997) found home care of SAM to cost US$29 per recovered child.

Table 6 Cost comparison by study group (US$)

Cost centre	Input	Unit of measurement	Community treatment Per unit (*N*)	Inpatient treatment Per unit (*N*)
Monitoring	Monitoring of CHWs	Child enrolled	22.20 (724)	12.14 (633)
	Cost centre total (% total)		**16 075 (13%)**	**7685 (10%)**
Training	For SCUS staff and CHWs	Child enrolled	19.20 (724)	14.80 (633)
	For UHC Staff	Child enrolled	0.72 (724)	0.88 (633)
	Cost centre total (% total)		**14 423 (12%)**	**9929 (12%)**
Supervision	Co-ordination meetings	Child enrolled	0.57 (724)	0.65 (633)
	Field supervisor time	Child enrolled	30.99 (724)	16.14 (633)
	Higher-level and support staff time	Child enrolled	17.60 (724)	10.06 (633)
	Overhead, institutional costs, capital depreciation	Child enrolled	16.76 (724)	11.13 (633)
	Cost centre total (% total)		**47 721 (40%)**	**24 046 (29%)**
GMP sessions	CHW time	GMP session	0.44 (3132)	0.25 (2940)
	GMP site rental	GMP session	0.53 (3132)	0.37 (2940)
	Cost centre total (% total)		**3043 (3%)**	**1803 (2%)**
Household visits	CHW time in visits (by case outcome in Table 2)			
	– Recovered	Total per outcome	1.49 (665)	0.56 (9)
	– Default	Total per outcome	1.48 (54)	5.30 (50)
	– Non-response	Total per outcome	4.50 (4)	5.50 (2)
	– Non-admitted	Total per outcome	–	5.30 (237)
	– Refused referral	Total per outcome	–	4.71 (335)
	– Death	Total per outcome	2.00 (1)	–
	CHW supplies and printing	Child enrolled	1.23 (724)	0.64 (633)
	Cost centre total (% total)		**1981 (2%)**	**3522 (4%)**
Curative care	*Community treatment*			
	RUTF	Child enrolled	36.38 (724)	–
	RUTF shipment and storage	Child enrolled	3.48 (724)	–
	Medicines from CHW	Child enrolled	0.65 (724)	–
	Inpatient treatment[a]			
	UHC setup equipment	Child enrolled	0.95 (724)	1.09 (633)
	Medicines from UHC	Inpatient case	1.50 (5)[a]	1.50 (61)
	Food for caretakers[b]	Child hospital day	0.55 (23)	0.55 (490)
	Bed costs	Child hospital day	0.74 (23)	0.74 (490)
	Therapeutic milk	Child hospital day	0.30 (23)	0.30 (490)
	Clinical staff salary:			
	– Admission	Inpatient case	1.64 (5)[a]	1.64 (61)
	– Daily care	Child hospital day	1.73 (23)	1.73 (490)
	Cost centre total (% total)		**30 109 (25%)**	**2505 (3%)**
Household costs[c]	*Community treatment*			
	Transportation[d]	Total per household	0 (724)	–
	Time[e]	Total per household	8.60 (724)	–
	Medicine and doctor's fees[d]	Total per household	0 (724)	–
	Food[d]	Total per household	0 (724)	–
	Inpatient treatment			
	Transportation[f]	Total per household	4.71 (5)	4.71 (61)
	Time[g]	Total per household	9.57 (5)	14.03 (61)
	Medicine and doctor's fees[h]	Total per household	0 (5)	0 (61)
	Food[b,i]	Total per household	4.05 (5)	5.16 (61)

(continued)

Table 6 Continued

Cost centre	Input	Unit of measurement	**Community treatment** Per unit (*N*)	**Inpatient treatment** Per unit (*N*)
	Visitors[j]	Total per household	5.29 (5)	8.50 (61)
	Other outpatient care[k]			
	Transportation[l]	Total per household	–	2.67 (624)
	Time[m]	Total per household	–	12.22 (624)
	Medicine and doctor's fees	Total per household	–	7.64 (624)
	Food	Total per household	–	26.92 (624)
	Cost centre total (% Total)		**6345 (5%)**	**32 834 (40%)**
TOTAL COSTS			***$119 697***	***$82 324***

Totals may not match added figures due to rounding.

Notes: [a]Inpatient costs in the community treatment group are for stabilization care at UHC for complicated cases of SAM.

[b]Costs for caretaker's meals during UHC stay were split between UHC and caretaker, based on evidence from focus group discussions.

[c]Household cost estimates reflect total costs per household using median cost estimates from focus group discussions.

[d]These costs were zero on average.

[e]Includes total time spent meeting with CHW and additional time feeding child RUTF according to CHW's advice.

[f]Costs incurred for caretaker and accompaniment (usually husband) for roundtrip travel via rickshaw to UHC for admission.

[g]Includes total time travelling to UHC, meeting with CHW, waiting for admission and staying at UHC.

[h]Costs were zero on average, although some bribes and outpatient medicine costs were reported.

[i]Includes food purchased for caretaker and accompaniment during travel to UHC, and food purchased by caretaker for self and child during UHC stay.

[j]Includes direct costs (food and transportation) for visitors (i.e. grandparents, fathers) assisting with child care.

[k]Costs incurred for other outpatient care for defaults, non-response, non-treated and refused referral cases.

[l]Includes total transportation costs for treatment-seeking and travel to UHC for cases not receiving admission.

[m]Includes the total value of caretaker's time in treatment seeking, meeting weekly with CHW, extra time feeding child according to CHW's advice, and time traveling to UHC and waiting for admission for those cases that did not receive admission.

CHW = community health worker; GMP = Growth Monitoring and Promotion; RUTF = ready-to-use therapeutic food; SAM = severe acute malnutrition; SCUS = Save the Children (US); UHC = Upazila Health Complex.

Table 7 Comparative cost-effectiveness outcomes, including an improved scenario for inpatient treatment (US$)

	Community treatment	**Inpatient treatment** ***Observed***	**Inpatient Treatment** ***Improved***[a]
Total cost	$119 697	$82 324	$90 973
Number of children treated	724	61	175
Number of children recovered from SAM	665	9	61
Deaths averted	138	2	12
	(115, 161)	(0, 5)	(6, 21)
Total DALYs averted	4683	67	418
	(3913, 5501)	(0, 172)	(203, 713)
Cost per child treated	**$165**	**$1344**	**$520**
	(151, 180)	(1119, 1580)	(434, 604)
Cost per child recovered	**$180**	**$9149**	**$1491**
	(164, 196)	(7582, 10 712)	(1249, 1733)
Cost per death averted	**$869**	**$45 688**	**$7276**
	(723, 1059)	(15 134, ∞)	(4209, 15 917)
Cost per DALY averted	**$26**	**$1344**	**$214**
	(21, 31)	(445, 3 788 726)	(124, 467)

Notes: Figures in parentheses are 95% CI for modelled estimates.

[a]These results are based on a modelled scenario, not actual programme outcomes, assuming a modest improvement of 20% to the coverage, recovery and default rates observed at facility level in the comparison upazila. See discussion for explanation.

However, this study differs from the present analysis in several important ways. First, the sickest children were excluded from Ashworth's analysis. The nature of the intervention in Ashworth's study also differs from CMAM programmes, with no RUTF used, and one week of inpatient day care provided before community treatment—a service that would be difficult to implement at scale across Bangladesh. Further, the present analysis includes additional costs, such as training, supervision, RUTF and its storage and distribution. Table 9 presents a summary of findings from CMAM costing studies.

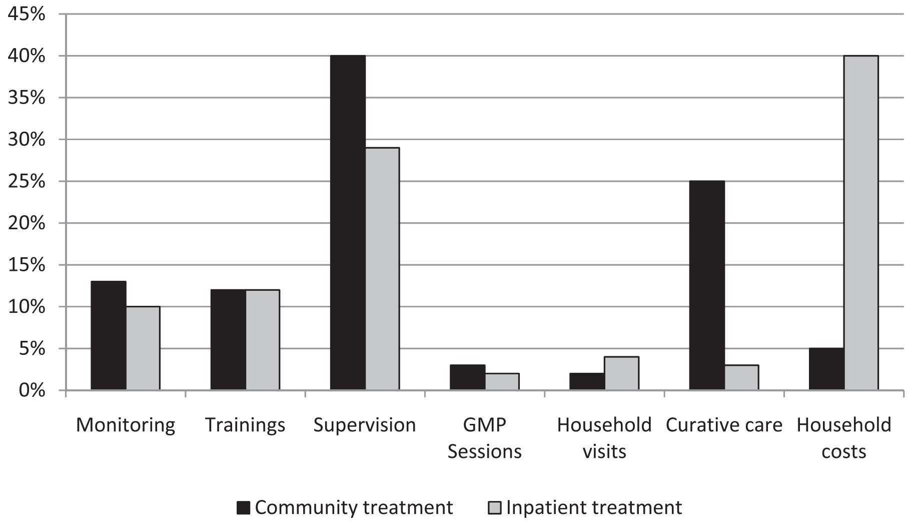

Figure 1 Cost centres as a percentage of total programme cost in both areas

Results from this study should be interpreted within the context of the overarching programme, with CHWs providing both preventive and curative care, and executing case-finding and treatment for SAM in the intervention area in a timely manner. Children that received treatment in the comparison group were younger, more malnourished and sicker at admission than those in the intervention group. This is likely due to the fact that the community case management of SAM intervention reduced barriers to accessing treatment, meaning that children were treated earlier along the continuum of the SAM episode and were therefore more likely to recover, and to recover quickly. Moreover, findings from linked analyses demonstrated that CHWs provided good quality of care for children suffering from SAM, without sacrificing the quality of other preventive and curative tasks in their workload (Puett *et al*., 2012; Puett *et al*., in press). This environment supported high recovery and coverage rates, and a low mortality rate, and is likely to have reduced the risk of cases of SAM presenting with medical complications (Sadler *et al*. 2011). Costs included in this analysis represent marginal costs required to add treatment of SAM to this programme, while effectiveness results represent this 'virtuous cycle' of programme factors.

Differing methodologies can make direct comparisons of cost-effectiveness outcomes a challenge. Nevertheless, if differences in outcomes are taken at face value, the lower costs per outcome for treatment of SAM in this study may be due in part to the aforementioned programmatic context, and particularly to the decentralized delivery model enabled by CHWs. Previous research supports this argument, finding that CHW programmes can achieve lower costs than comparable clinic-based services (Berman *et al*. 1987), with similar outcomes (Islam *et al*. 2002). Due to their proximity to communities and the low cost of their time compared with clinical staff, community workers can expand the coverage and equity of health services at low overall cost, removing barriers to access such as distance, travel and opportunity costs for poor and remote households. In Indonesia, CHWs were consulted for simple curative care more often than any other source of treatment. Further, they showed no bias against low-income patients in contrast to clinic-based services (Berman 1985 as cited in Berman *et al*. 1987). These factors contribute to increased programme utilization, coverage and effectiveness.

The sensitivity of the DALY calculation to the number of deaths anticipated without treatment is consistent with findings from other studies (Bachmann 2009; Wilford *et al*. 2011), and is plausible for a condition affecting children associated with high mortality but little or no lasting disability among survivors. As with these other analyses, this calculation used the most appropriate mortality estimates available, from relevant historical cohort studies. Even assuming a halved mortality estimate, the cost per DALY averted by community treatment of SAM (US$53) would remain highly cost-effective according to common standards (Bobadilla *et al*. 1994; Commission on Macroeconomics and Health 2001).

Cost analysis

RUTF is a high-cost input and typically comprises 30 to 40% of costs for CMAM programmes (Tekeste 2007; Bachmann 2009; Horton *et al*. 2010; Wilford *et al*. 2011). In Bhola, RUTF-related costs comprised only 24% of total costs. This difference is due in part to the high proportion of management costs in this intervention, including salaries and overheads (53%, combining monitoring and supervision cost centres). This compares with findings from Zambia estimating technical support at 34% of total costs (Bachmann 2009), and Malawi where administration, personnel and overhead comprised 51% of total costs (Wilford *et al*. 2011). This suggests that the community case management of SAM was relatively management-heavy. However, these supervision costs represent the intensive start-up costs needed in the first year of a programme to establish new systems, and include costs for several management staff dedicated to overseeing activities related to SAM management. This cost structure would likely change over time due to economies of scale, as SAM treatment is integrated into ongoing non-government organization (NGO) or government programmes. Field-level monitoring of CHWs, which enabled them to regularly ask questions of their supervisor and to maintain confidence in their case management skills, was a

Table 8 Household costs in accessing SAM treatment, reported in focus group discussions[a] (US$)

Cost	Community treatment $N^{b}=28$, 4 FGDs median (range)	Inpatient treatment $N=21$, 4 FGDs median (range)	Other outpatient care $N=25$, 3 FGDs median (range)
Direct costs:			
One-time costs:			
Transportation to UHC (round trip)		2.35 (0.24–7.36) $n^{c}=21$	
Food purchased while travelling to UHC		1.47 (0.37–7.36) $n=21$	
Food purchased for self during UHC stay		0.74 (0–4.78) $n=19$	
Food purchased for child during UHC stay		0.74 (0–11.04) $n=21$	
Total bribes paid at UHC[d]		0.66 (0.44–1.91) $n=7^{e}$	
Transportation to seek treatment for illness	–	–	0.88 (0–2.94) $n=24$
Total medicines purchased (post-treatment)	0.44 (0, 2.50) $n=6^{e}$	8.32 (0–39.74) $n=21$	4.42 (0.52–36.80) $n=24$
Total doctors' fees paid (post-treatment)	0 $n=6^{e}$	0.74 (0–2.94) $n=19$	0 (0–2.21) $n=23$
Weekly costs:			
Extra food purchased for child	0 $n=28$	1.47 (0.59–5.89) $n=21$	1.77 (0–7.36) $n=22$
Indirect costs: caretaker's time			
Travel one-way to UHC (hours)		2 (0.5–3) $n=21$	
Waiting at UHC for admission (hours)		2 (0–6) $n=21$	
Staying at UHC during treatment (days)		7 (4–15) $n=21$	
Time per CHW household visit (min.)	45 (20–90) $n=26$		75 (30–120) $n=20$
Traveling to seek treatment for child (min.)	2.5 (0–60) $n=6^{e}$		60 (0–360) $n=24$
Extra time per day feeding SAM child (min.)	45 (30–160) $n=22$		39 (0–150) $n=14$

Notes: [a]These estimates are from focus group discussions and the sample may not be representative of all caretakers in the programme area. These provide a summary of the median value and ranges for key costs incurred by caretakers.
[b]*N* (uppercase) represents total caretakers responding in all focus group discussions for each of the three groups.
[c]*n* (lowercase) represents caretakers providing a response to each cost item.
[d]Bribes were paid for hospital bed, food, admission, mosquito net, therapeutic milks.
[e]These values were only reported for those caretakers for whom this question was applicable (e.g. those whose child had been ill, those who paid bribes).
CHW = community health worker; FGD = focus group discussion; SAM = severe acute malnutrition; UHC = Upazila Health Complex.

relatively small proportion of overall costs, at 13%. Further, actual service provision by CHWs at household visits and Growth Monitoring and Promotion sessions made up only 5% of total costs, suggesting that the ongoing service delivery resources required to add community case management of SAM to an existing programme were relatively low.

Proper supervision is important for CHWs (Berman *et al*. 1987), with effective community programmes paying careful attention to their training and support (Mason *et al*. 2006). The costs of building human and community capacity are expected to be the primary costs in programmes involving community mobilization (Rosato *et al*. 2008). Further, motivated CHWs, receiving adequate training and supervision as was seen in this study, have been necessary to ensure quality community management of SAM in previous studies (Ashworth and Khanum 1997). These lessons are of particular

Table 9 Comparison of cost-effectiveness results for community-based management of acute malnutrition (CMAM) (US$)

Cost outcome	Bhola[a]	Bangladesh	Ethiopia	Malawi	Zambia
Per recovery	$180	$29[b]	$145		
Per treated case	$165				$203
Per DALY averted	$26			$42	$53

Notes: [a]These results are from the present analysis.
[b]Results from this study are not exactly comparable due to different programme models and included costs. See discussion.
Data cited are from the following sources: (Ashworth and Khanum 1997; Tekeste 2007; Bachmann 2009; Wilford *et al*. 2011)

importance when integrating preventive and curative care (Mason *et al*. 2006), and suggest that strong supervision can help to ensure that both components receive equal attention.

The UHC in the comparison upazila was supported with training, staff, money, therapeutic milk and drugs, and can be said to have been 'improved'. However, its poor effectiveness and cost-effectiveness were due in part to low utilization by the community. There are well-documented reasons for caretakers of children suffering from SAM to refuse inpatient care. These include perceptions of hospital quality, perceptions of the costs of treatment and transport, loss of earnings and other responsibilities at home (Ashworth 2006; Sadler *et al*. 2011). There is also evidence that inpatient treatment of SAM can be improved by implementing WHO guidelines and providing adequate personnel, supervision and beds (Ahmed *et al*. 1999; Ashworth *et al*. 2004). To this end, an improved scenario was modelled for cost-effectiveness outcomes for inpatient treatment (Table 7). These results show that even if it were possible, given all the constraints, to improve quality of care for SAM at the UHC, the community treatment of SAM would remain over eight times more cost-effective than inpatient treatment in this setting. Limited capacity and resource constraints at facility level point to a need to consider viable alternatives. This study adds to the growing evidence that community treatment can be more effective than inpatient treatment for most cases of SAM (Collins *et al*. 2006a; Collins *et al*. 2006b; WHO *et al*. 2007).

Household costs made up a large proportion (40%) of costs involved in inpatient treatment. Household costs to recover a child from SAM in inpatient treatment were six times those for community treatment (US$49.72 and US$8.50, respectively, data not shown). Costs were even higher for the majority of cases who defaulted from the UHC and hence bore costs for both inpatient treatment and other outpatient care. The finding that household costs are higher for inpatient treatment is consistent with other studies. In Ethiopia, direct household costs for inpatient cases were over twice those of outpatient cases. Opportunity costs to caretakers enrolled in CMAM, including wage loss and transportation, were approximately one-quarter the amount of those receiving inpatient treatment (Tekeste 2007). In Ashworth and Khanum's analysis in Bangladesh, household costs for outpatient care were three times higher than inpatient care since caretakers paid for additional food. Notwithstanding these higher costs, caregivers preferred this option because it allowed them the convenience of staying at home (Ashworth and Khanum 1997).

The absence of long inpatient stays was a big part of the appeal of community treatment to caretakers in the present study. During FGDs, they expressed appreciation for the CHWs delivering services to their doorstep, especially in more conservative Muslim communities where women may not be permitted to leave their homes. It is likely that these women would not have accessed treatment for a case of SAM without this decentralization, unless their children were severely ill.

Future research

This study analysed costs from the societal perspective for an innovative delivery strategy for CMAM in Bangladesh. Given the disparity in effectiveness (in terms of recovery rate) between community and inpatient treatment, comparative measures of incremental costs and health effects between the two programmes were not included. Future comparative studies are needed to explore the relative cost-effectiveness of different CMAM models, such as different coverage levels, different service delivery mechanisms, or treatment of SAM alone vs the addition of treatment of moderate acute malnutrition. Further research should be conducted in other settings, and over longer periods of time, to assess whether any changes in cost-effectiveness occur as management of SAM is well-integrated into the management structure of the programme. Lastly, future research should be conducted to track the cost of bringing CMAM programmes to scale, to assist policy-makers in prioritizing interventions within national budget constraints.

Conclusion

The community case management of SAM by CHWs was a cost-effective strategy compared with inpatient treatment and compares well with the cost-effectiveness of other common child survival interventions. This experience has demonstrated that in an effective programme CHWs can identify and admit children suffering from SAM before they develop complications and can treat them effectively. Households accessing SAM treatment through CHWs incurred considerably lower expenses than those accessing care from the inpatient facility or elsewhere.

Performance at the inpatient facility was poor. Even assuming improved coverage, recovery and default rates, cost-effectiveness outcomes were still not comparable with those achieved via community treatment.

The community case management of SAM is a feasible mechanism for delivering cost-effective treatment to large numbers of children with SAM in countries like Bangladesh, and appears suitable for integration into common packages of preventive and curative care delivered at community level. Providing a dedicated corps of community health workers with good training and supervision should be prioritized as a viable way to expand access to treatment for SAM in Bangladesh. The integration of such a strategy into the recently-developed five-year national plan for the health, nutrition and population sector in Bangladesh should be considered by policy-makers and their partners.

Supplementary Data

Supplementary data are available at *Health Policy and Planning* Online.

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Conflict of interest

None declared.

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