Cost Effectiveness Analysis of the Community-based Management of Acute Malnutrition (CMAM) Surge Approach

Ethiopia

Final Report

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This report was prepared by Jean Christophe Fotso and Mark Myatt

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List of Acronyms

CEA	Cost-effectiveness analysis
CMAM	Community-based management of acute malnutrition
Concern	Concern Worldwide
CTC	Community-based Therapeutic Care
DALY	Disability adjusted life year(s)
EBT	Ethiopian Birr
EVIHDAF	Evidence for Sustainable Human Development Systems in Africa
GAM	Global acute malnutrition
MAM	Moderate acute malnutrition
FMoH	Federal Ministry of Health
NGO	Non-governmental organization
OTP	Outpatient therapeutic program
RUTF	Ready-to-use therapeutic food
SAM	Severe acute malnutrition
SC	Stabilization Center
UNICEF	United Nations Children's Fund
YLD	Years lived with the disability
YLL	Years of life lost

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Executive Summary

Severe acute malnutrition (SAM), caused by a decrease in food consumption and/or illness, threatens the survival of children under-five years of age in developing countries. The effectiveness of the community-based management of acute malnutrition (CMAM) approach to treating SAM has been established since 2007 following an endorsement by United Nations agencies, which provided a framework for the expansion of the intervention. Drawing from this experience implementing CMAM in more than 16 countries over the last 15 years, Concern developed the CMAM Surge approach, which seeks to support health systems to become more resilient by helping them to better manage seasonal 'surges' in the demand for treatment of acute malnutrition that occur in many setting in where CMAM programs are implemented. While previous assessments have shed light on its ability to respond to increases in caseload, an equally critical question of whether the Surge approach offers similar levels of cost-effectiveness as other models for delivering CMAM services remains to be answered. This report presents results for Ethiopia. The study compares the cost-effectiveness of the CMAM Surge approach in Ethiopia to the more traditional CMAM response often implemented by NGOs, and to international standards and CEA results from a variety of CMAM programs in other countries that did not use the Surge approach.

The study is a comparative cost effectiveness analysis of the CMAM Surge Approach, comparing the following two program delivery models:

- Delivery of services for SAM via the government health system with the integration of the CMAM Surge approach (the 'intervention Woreda' or CMAM Surge arm: Bati woreda)
- Delivery of services for SAM via the government health system with standard CMAM service support provided by Concern ('the comparison Woreda' or traditional CMAM arm: Dewa Chefa woreda).

We adopted an approach to costing which encompasses both the intuitional and societal costs. Costs in local currency, the Ethiopian Birr (ETB) were converted into US dollars using an exchange rate of 1USD = 28.06ETB. The outcomes of interest to the study are number of children cured, number of deaths averted (number of lives saved), and number of disability adjusted life years (DALYs) averted. The principal outcome of interest is the number of DALYs averted.

The 'No-frills' approach was used (i.e. age-weighting and discounting were not used) for DALY calculations. In this study, uncertainty was accounted for by the use of fuzzy triangular numbers (informed by literature review and analysis of the collected data) and propagated through calculations using fuzzy (interval) arithmetic. Estimates of results with 95% confidence intervals were made using a geometric method to find the central 95% of the triangular distribution represented by a fuzzy triangular number.

Our measures of cost-effectiveness (CE) are defined as:

$$CE = \frac{cost}{outcomes}$$

They are calculated by dividing the total cost by the number children cured, the number of deaths averted (number of lives saved), and the number of DALYs averted.

The total cost is estimated at $227,905.20 in the Bati woreda and $160,508.20 in the Dewa Chefa woreda. The cost per DALY is estimated at $21.58 in the intervention site and $10.75 in the control area. Both programs are highly cost-effective as explained below, and the fact that the Surge program is less cost-effective than the control program, is partly due the difference in cost base, with the Surge program, as a pilot, requiring additional set up costs.

Cost-effectiveness estimates are usually interpreted by comparison with other programs and/or against commonly used standard or threshold values.

It is common to use standard (threshold) values. Two standards are commonly used:

- **A single fixed standard for cost per DALY averted**: Interventions achieving a cost per DALY averted of less than US$100 at the time of analysis are classified as being very cost-effective [i]. The cost per DALY averted achieved by the current CMAM/Surge program was US$21.58. This program would, therefore, be classified as being very cost-effective.
- **Variable standard per DALY averted**: The most commonly-used standard in the public health nutrition field is one proposed by the WHO [ii]. This compares the cost per DALY averted by an intervention with the per capita GDP of the country in which the intervention is implemented:
  - Highly cost-effective interventions avert a DALY for less than a country's GDP per capita.
  - Cost-effective interventions avert a DALY for between one and three times a country's GDP per capita.
  - Intervention that are not cost-effective avert a DALY for more than three times a country's GDP per capita.

The proportion of GDP required to avert one DALY by the current Surge program is 0.0280 (i.e. 2.80% of GDP). The Bati woreda CMAM Surge program can, therefore, be considered to be highly cost-effective.

In conclusion, the Ethiopia CMAM Surge program as implemented in Bati woreda appears to be a very cost-effective strategy. The cost-effectiveness of the CMAM services, including CMAM Surge within the 32 OTP and 2 SC sites is still acceptable in relation to global benchmarks/standards and in comparison to CMAM programs without CMAM Surge.

1. Introduction

Severe acute malnutrition (SAM), caused by a decrease in food consumption and/or illness, threatens the survival of children under-five years of age in developing countries. The effectiveness of the community-based management of acute malnutrition (CMAM) approach to treating SAM has been established since 2007 following an endorsement by United Nations agencies, which provided a framework for the expansion of the intervention [3]. The cost-effectiveness of the CMAM intervention model has been proven and documented by a number of studies [4,5,6].

Concern Worldwide has been at the forefront in the fight against child malnutrition in many countries, and was one of the first non-governmental organizations (NGO) to pilot the CMAM model [7,8]. Drawing from this experience implementing CMAM in more than 16 countries over the last 15 years [9], Concern developed the CMAM Surge approach, which seeks to support health systems to become more resilient by helping them to better manage seasonal 'surges' in the demand for treatment of acute malnutrition that occur in many setting where CMAM programs are implemented [10,11]. This approach is currently being implemented by Concern in Burundi, Chad, Ethiopia, Kenya, Pakistan, and Niger and has also been introduced by other organizations in other countries. While previous assessments have shed light on its ability to respond to increases in caseload [12,13], an equally critical question of whether the Surge approach offers similar levels of cost-effectiveness as other models for delivering CMAM services remains to be answered. EVIHDAF was commissioned by Concern to develop a practical cost-effectiveness analysis (CEA) framework, protocol, and related analytical tools, and to lead on its immediate application to CMAM Surge programs in Ethiopia and Niger. This report presents results for Ethiopia. The study compares the cost-effectiveness of the CMAM Surge approach in Ethiopia to the more traditional CMAM response often implemented by NGOs, and to international standards and CEA results from a variety of CMAM programs in other countries that did not use the Surge approach.

2. Concern's CMAM Surge Intervention in Ethiopia

CMAM, then called Community-based Therapeutic Care (CTC), was first piloted by Concern and Valid International in Ethiopia in 2000 [5]. Since then, the Federal Ministry of Health of Ethiopia (FMoH) has led the national scale up of CMAM, and community-based management of SAM is now an integrated service within the Government health system. CMAM Surge approach is being piloted by Concern in Amhara Region of Ethiopia, in collaboration with the Federal Ministry of Health of Ethiopia (FMoH), Ethiopia Public Health Institute, and actors at regional, zonal and woreda levels. Specifically, the pilot is being implemented in Bati woreda (intervention area) with Dewa Chefa woreda serving as comparison ("control") area. The

number of outpatient therapeutic program (OTP) sites (health centers (HCs) and health posts (HPs)) and stabilization center (SC) sites in these two areas is shown in Table 1.

Table 1. Number of OTP and SC centers by woreda

Level	Bati (Intervention Woreda)	Dewa Chefa (Comparison Woreda)	Total
Health centers (HCs)	6	7	13
Health posts (HPs)	26	27[a]	53
Total OTP centers	32	34	66
SC sites	6	7	13

[a]Two new facilities were added during the study period.

3. Methodology

3.1. Study design and setting

The study is a comparative cost effectiveness analysis of the CMAM Surge Approach, comparing the following two program delivery models:

- Delivery of services for SAM via the government health system with the integration of the CMAM Surge approach from the outset to support better planning and response to periodic caseload surges (the 'intervention Woreda' or CMAM Surge arm: Bati woreda). The intervention ran from April 2018 to June 2019.
- Delivery of services for SAM via the government health system with standard CMAM service support provided by Concern ('the comparison Woreda' or traditional CMAM arm: Dewa Chefa woreda). The intervention started in April 2018 and ended in December 2018.

Concern's CMAM Surge Approach Value for Money framework [14] guided the development of the study protocol and tools. Data collection was carried out in both study arms over a period of 12 months, to ensure we covered an entire seasonal cycle.

3.2. Costs data

3.2.1. Cost approach

We adopted an approach to costing which encompasses both the intuitional and societal costs, as detailed in Table 2.

Table 2. Description of institutional and societal costs

Type of cost	Cost items
1. Institutional costs	
MOH – OTP and SC sites	• Time of clinical staff involved in CMAM service delivery. • Supervision and monitoring visits by clinical staff involved in CMAM service delivery • Supply delivery and collection for CMAM service delivery • Health management information systems for CMAM service delivery
MOH – Woredas	• Time of managerial staff involved in CMAM service delivery • Supervision and monitoring visits by managerial staff of CMAM service delivery • Supply delivery and collection for CMAM consumables • Health management information systems for CMAM service delivery
Concern	• Time of national staff at Concern working on CMAM. • Training, supervision and monitoring visits by Concern • Supplies and equipment delivery and collection by Concern • Training and meetings by Concern
UNICEF	• CMAM supplies (RUTF, antimicrobials, anthelminthics, Vitamin A, therapeutic feeding milks …) for OTP and SC sites. • CMAM miscellaneous consumables for OTP sites, SC, and community sensitization/mobilization.
2. Societal costs	
Caregivers at OTP	• Travel time and costs to/from OTP sites • Time and out-of-pocket expenses at OTP sites
Caregivers at SC	• Travel time and costs to/from the SC • Time and out-of-pocket expenses at the SC
Community volunteers	• Time spent on CMAM activities and in training • Transportation for CMAM activities

Details on the specific costs covered can be seen in the questionnaires and forms for data collection presented in Annex A.

3.2.2. Data collection

The primary data collection schedule with woredas, health facilities, community volunteers and caregivers is shown in Table 3. Data extraction (e.g. from OTP/SC registers) was also undertaken during the same period. Questionnaires and forms for data collection are presented in **Annex A**.

Table 3. Cost data sources

Type of cost	Data source / methods
1. Institutional costs	
MOH – OTP sites	Structured interviews with nutrition focal points at OTPs – Data collected from Feb. 27, 2018 to Sept. 3, 2018: 30 sites (6 HCs and 24 HPs) in Bati; 30 sites (7 HCs and 23 HPs) in Dewa Chefa (See Tool #1 in Annex A).
MOH – Woredas	Structured interviews with nutrition focal points at SCs – Data collected twice in each woreda office: March 6 and Nov. 23 in Bati; March 12 and Nov. 23 in Dewa Chefa (See Tool #2 in Annex A).
Concern	Concern's accounting records for April 2018 to March 2019 covering all NGO costs associated with the delivering of the CMAM Surge program. Surge setup and planning costs between August 2017 and March 2018 for Bato woreda are also included.
UNICEF	UNICEF's accounting records for the 12-month period April 2018 to March 2019 covering all UNICEF logistics costs associated with the delivering of CMAM to each of the two woredas.
2. Societal costs	
Caregivers at OTP	Structured interviews with caregivers at OTPs - Data collected from Feb. 27, 2018 to Aug. 25, 2018: 81 caregivers from 4 HCs and 26 HPs in Bati; 71 caregivers from 6 HCs and 23 health in Dewa Chefa (See Tools #4a in Annex A).
Caregivers at SC	Structured interviews with caregivers at SCs - Data collected from March 8, 2018 to Oct. 7, 2018: 3 caregivers from 2 HCs in Bati; 3 caregivers from 3 HCs in Dewa Chefa (See Tools #4b in Annex A)
Community volunteers	Structured interviews with community-based volunteers (CBVs) - Data collected from Feb. 27, 2018 to Aug. 25, 2018: 83 CBVs attached to 23 HPs in Bati; 74 CBVs attached to 27 HPs in Dewa Chefa (See Tool #3 in Annex A).

3.3. Effectiveness

The outcomes of interest to the study are number of children cured, number of deaths averted (number of lives saved), and number of disability adjusted life years (DALYs) averted. The principal outcome of interest is the number of DALYs averted. Data sources are presented in Table 4. The forms used for data extraction are in Annex A.

Table 4. Effectiveness data sources

Type	Data source / methods
Admissions at OTP	Data extracted from OTP registers for the period January 17, 2018 to September 21, 2018 on admissions, admission MUAC, lengths of stay, and attendance rates: 258 episodes from 6 HCs and 26 HPs in Bati; 118 episodes from 6 HCs and 23 HPs in Dewa Chefa (See Tools #5a in Annex A)
Admissions at SC	Data extracted from SC registers for the period May 1-31, 2018 on admissions, admission MUAC, lengths of stay, and attendance rates: 1 episode from 1 SC in Bati; 3 episodes from 2 SCs in Dewa Chefa (See Tools #5b in Annex A)
Outcomes (i.e. cured and not-cured)	Routine program monitoring data

3.4. Analytical strategy

3.4.1. Cost

Costs in local currency, the Ethiopian Birr (ETB) were converted into US dollars using the 15th November 2018 mid-market exchange rate of 1USD = 28.06ETB retrieved from www.xe.com. Annex B1 summarizes the cost categories and their aggregation into total costs. All costs were adjusted to give annual costs.

- **Woreda and OTP costs:** Using Ethiopia's official mid-point salary for each staff grade, staff cost was calculated based on the hours worked and expressed as a fractional fulltime equivalent salary based on a 40-hour working week. Data collection focused on CMAM-related activities. Annex B2 shows the method for aggregating district and OTP costs.
- **SC costs:** Same method as OTP costs.
- **Community volunteer costs:** Data collection focused on CMAM-related activities. A daily shadow wage of ETB37 was used (based on the "Safety Net" of ETB185 for five days work). An hourly shadow wage was derived from the daily shadow wage and an eight-hour working day (i.e. ETB4.63 per hour). The OTP centers have a combined total of 1453 active volunteers (890 in Dew Chefa woreda and 563 in Bati woreda). Annex B3 shows the method for calculating the total community volunteer costs.
- **Caregivers at OTP and SC:** The same shadow wage for community volunteers (see above) was used (see Annexes B4a and B4b).
- **Delivery costs (UNICEF):** UNICEF provided a detailed Excel™ file covering all CMAM supplies and consumables (with costs) delivered to the two woreda during the period April 2018 to March 2019. This was used to calculate the average cost to purchase and deliver key CMAM supplies (i.e. RUTF, therapeutic milk, vitamin A, antimicrobials, anthelminthics, ReSoMal, patient record cards, clinic registers, and clinic equipment required to deliver the CMAM protocol) and was combined that with woreda delivery data to estimate supply costs for each woreda separately.

- **Concern's costs:** Concern provided an Excel™ file detailing expenditures on CMAM activities in each woreda. Data on expenditures between April 2018 and March 2019 were used. Data relating to expenditure between August 2017 and March 2018 on CMAM/Surge setup and planning activities were also used for Bati woreda.

3.4.2. Effectiveness

Cure rates and the number cured for the target OTP centers were estimated from routine program monitoring data. The concept of cure rate is not relevant for SC admissions, as children referred for stabilization returned to their OTP site for continued treatment. Deaths, onward referrals, default from SC and/or failure to return to OTP were treated as not-cured.

The number of deaths averted (number of lives saved) by the program was calculated by multiplying the number cured by the expected mortality estimated using data from four historical cohort studies of untreated cases of SAM [3,15,16,17,18,21] at the average admission MUAC and correcting for a background mortality of 1 /10,000 / day (i.e. the approximate average under five-years mortality rate for the locations and times of the four historical cohorts).

The number of DALYs averted by the program was calculated using both years of life lost (YLL) and years living with disability (YLD) components (see Annex B5):

- YLL was calculated using the estimated number of deaths averted (see above), age at admission, time to death for an *untreated* SAM episode (minimum = 0 months; median = 2 months; maximum = 7.5 months) and the sex-combined 2017 Ethiopia life-expectancy at birth 72.282 years taken from the World Bank database [19].Expected mortality rates for the average MUAC at admission was taken from historical cohort studies and corrected for a background mortality of 1 death per 10,000 children per day [3,20,21,22,23,21].
- YLD was calculated using the number cured, an assumed average duration of an *untreated* SAM episode (min = 3.5 months; median = 6 months; maximum = 7.5 months), the observed length of stay of SAM cases, and the disability weight for severe acute malnutrition (SAM) taken from the 2010 Global Burden of Disease (GBD) study [24].

The 'No-frills' approach was used (i.e. age-weighting and discounting were not used) for both YLL and YLD calculations [15]. This approach reflects the current thinking and practice in CEA and global burden of disease work. DALYs averted were calculated as the sum of the YLL and YLD components.

In this study, uncertainty was accounted for by the use of fuzzy triangular numbers (informed by literature review and analysis of the collected data) and propagated through calculations

using fuzzy (interval) arithmetic. Estimates of results with 95% confidence intervals were made using a geometric method to find the central 95% of the triangular distribution represented by a fuzzy triangular number [25,26]. See Annex C for further details.

3.4.3. Cost-effectiveness analysis

Our measures of cost-effectiveness (CE) are defined as:

$$CE = \frac{cost}{outcomes}$$

They are calculated by dividing the total cost by the number children cured, the number of deaths averted (number of lives saved), and the number of DALYs averted.

4. Results

4.1. Costs

The total cost of the CMAM program with Surge components in the 32 OTP and two SC sites, as detailed in **Table 5**, is estimated at $227,905.20 in the Bati woreda and $160,508.20 in the Dewa Chefa woreda.

Table 5. Institutional and societal costs (US$)

	Cost (Lowest, Middle, Highest)	
Cost type	Bati (Intervention woreda)	Dewa Chefa (Comparison woreda)
1. Institutional costs		
MOH - Facilities[a]	($28,896.40 **$32,107.11** $35,317.82)	($19,827.69 **$22,030.77** $24,233.85)
MOH – Woredas[a]	($5,024.70 **$5583.00** $6,141.30)	($11,526.86 **$12,807.63** $14,088.39)
Concern[b]	($119,656.70 **$119,656.70** $119,656.70)	($31,587.38 **$31,587.38** $31,587.38)
UNICEF[b]	($40,650.86 **$40650.86** $40,650.86)	($72,172.15 **$72,172.15** $72,172.15)
Total[c]	($194,228.60 **$197,997.60** $201,766.70)	($135,114.10 **$138,597.90** $142,081.80)
OTP beneficiaries[d]	($1,976.07 **$2,484.37** $3,041.67)	($1,956.60 **$2,543.59** $3,205.94)
SC beneficiaries[d]	($688.05 **$883.29** $1,078.52)	($252.73 **$418.67** $584.62)
CBVs[d]	($17,901.85 **$26,539.85** $35,177.86)	($12,618.97 **$18,948.05** $25,277.13)
Total societal costs[c]	($20,565.97 **$29,907.51** $39,298.05)	($14,828.30 **$21,910.31** $29,067.69)
Total costs[c]	($214,794.60 **$227,905.20** $241,064.70)	($149,942.40 **$160,508.20** $171,149.50)

Note: Numbers presented are fuzzy triangular numbers

[a]Uncertainty incorporated as ± 10% of the point estimates.

[b]Assumed to be measured without error

[c]Sums calculated using fuzzy (interval) arithmetic to model uncertainty

[d]Uncertainty incorporated using fuzzy triangular numbers of the form:

$$(median(cost) - 2 \times SE(cost), median(cost), median(cost) + 2 \times SE(cost))$$

where:

$$SE(cost) = \frac{median\ absolute\ deviation(cost) \times 1.4826}{\sqrt{sample\ size}}$$

for each parameter in the cost equation.

4.2. Effectiveness

Effectiveness outcomes are presented in **Table 6**. These estimates are used as the denominator for the cost-effectiveness outcomes.

Table 6. Effectiveness outcomes

	(Lowest, Middle, Highest)	
Outcome	Bati (Intervention woreda)	Dewa Chefa (Comparison woreda)
Number of children treated	891	1,286
Number of children cured	(626 652 678)	(1,165 1,184 1,203)
Number of deaths averted	(102 148 217)	(135 209 290)
Number of DALYs averted	(8,038 10,559 14,541)	(10,754 14,934 19,539)

Note: Numbers presented are fuzzy triangular numbers

4.3. Cost-effectiveness

Cost-effectiveness results are shown in Table 7.

Table 7. Cost-effectiveness results

	Cost (Lowest, Middle, Highest)	
	Bati (Intervention woreda)	Dewa Chefa (Comparison woreda)
1. Cost per child cured		
Point estimate	$349.55	$135.56
95% Confidence interval	[$324.28 $377.30]	[$127.11 $144.40]

	Cost (Lowest, Middle, Highest)	
	Bati (Intervention woreda)	Dewa Chefa (Comparison woreda)
2. Cost per death averted		
Point estimate	$1,539.90	$767.98
95% Confidence interval	[$1,127.27 $2,195.22]	[$585.67 $1,170.92]
3. Cost per DALY averted		
Point estimate	$21.58	$10.75
95% Confidence interval	[$16.38 $28.20]	[$8.47 $14.88]

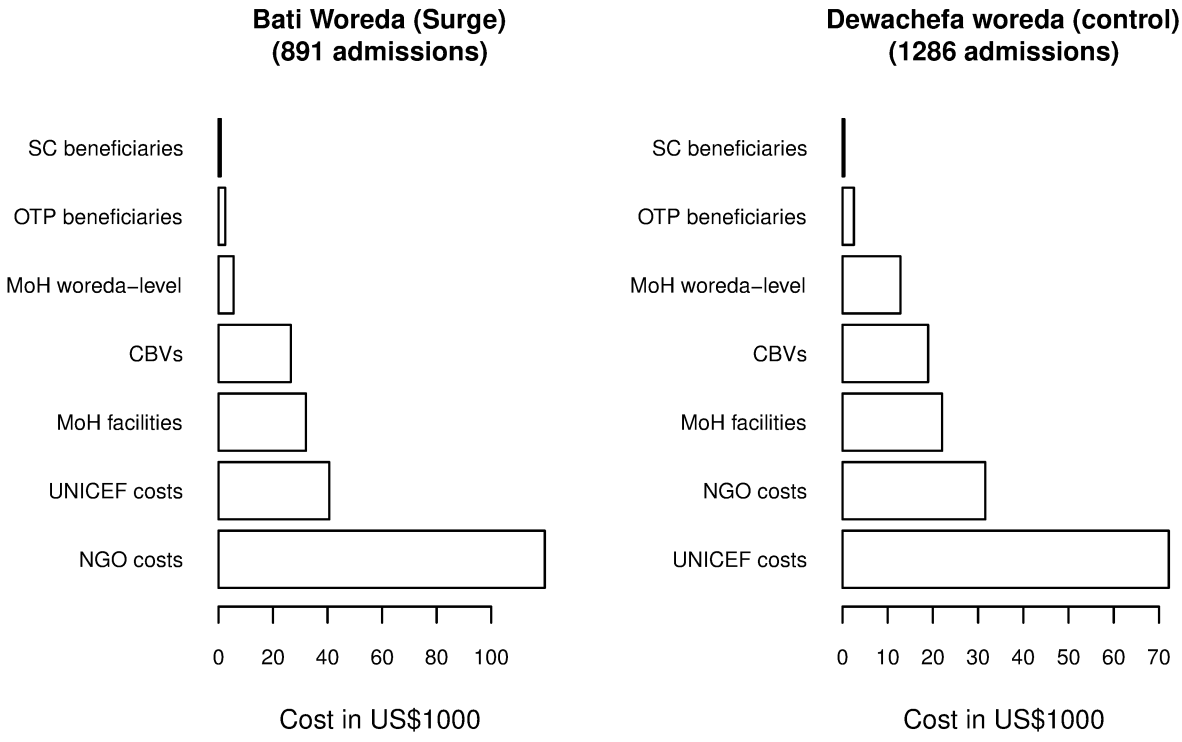
5. Discussion

Both CMAM programs studied were found to be very cost-effective. The Surge program ($21.58 per DALY averted) was less cost-effective than the control program ($10.75 per DALY averted). The 95% confidence intervals of the two estimates ([$16.38 $28.20] and [$8.47 $14.88]) not overlapping, the observed difference in cost-effectiveness is unlikely to be due to chance.

Some of the difference in cost-effectiveness between the two programs can be accounted for by inclusion in the analysis of costs for CMAM Surge program setup and planning activities between August 2017 and March 2018 as well as the cost of Surge-specific activities over the study period (US$26,133.17) in the Surge woreda. This represents about 13.2% of all institutional costs in the Surge woreda. It is important to note that the magnitude of Surge-specific costs may be high because this was a pilot program for both the NGO and its MoH partner. These costs can reasonably be expected to be lower later in the program cycle and in subsequent programs as experience is gained in implementing Surge type programs.

A direct comparison of costs in each woreda reveals considerable differences in costs (see Table 5 and Figure 1). NGO costs were much higher in the Surge woreda than in the control woreda. This reflects the level of NGO support given to the Surge program. For example, local staff costs were US$38,737.61 (Surge) and US$16,601.83 (control); transport costs were US$47,397.15 (Surge) and US$6,378.68 (control); and costs for training given to MoH staff were US$ 16,234.80 (Surge) and US$3,335.65 (control). The NGO was probably undertaking many of the program support activities in the Surge woreda that would usually be covered by the woreda health office. This is reflected in the higher NGO costs and lower MoH woreda-level costs seen in the Surge woreda. This pattern was also seen in in the Niger pilot of the CMAM surge model. UNICEF's costs are dominated by CMAM supplies and the difference in UNICEF's costs between the two programs reflects the number of program admissions in each woreda.

Figure 1: Comparison of cost-centers in two CMAM programs



Cost-effectiveness estimates are usually interpreted by comparison with other programs and/or against commonly used standard or threshold values [22]. Table 8 shows the cost per child cured, cost per death averted and cost per DALY averted for the current program and five other CMAM programs. Typically, CEA concentrates on the cost per DALY averted metric since this allows comparisons to be made across a wide range of interventions.

Simple comparisons are not straightforward as results are influenced by both methods (e.g. the disability weights used, whether age-weighting and discounting were used, which life-expectancy (LE) was used, and the extent of the costs-base used) and by settings (e.g. local life-expectancy, MUAC at admission, program cure rates, and miscellaneous program factors) [23].

Table 8. Cost-effectiveness results from other studies

Study	Country	Cost per child cured	Cost per death averted	Cost per DALY averted
Current study, 2019	Ethiopia – Bati[a]	$349.55	$1,539.90	$21.58
	Ethiopia-Dewa Chefa[b]	$135.56	$767.98	$10.75
CEA CMAM study, 2018 [27]	Niger	$165	$1,567	$26
Rogers et al., 2018 [2]	Mali	$214	Not available	
Frankel et al., 2015 [4]	Nigeria	$219	$1,117	$30
Puett et al., 2012 [3]	Bangladesh	$180	$869	$26
Wilford et al., 2011 [28]	Malawi	$185	$1,365	$42
Bachmann, 2009 [29]	Zambia	$203	$1,760	$53

[a]Interention woreda

[b]Control woreda

The use (or not) of age-weighting and discounting and the choice of local life-expectancy or the standard expected years of life lost (SEYLL) have large effects of DALY calculations [30]. The choice of disability weight used is of much less importance for acute conditions, such as SAM, that are associated with short durations of disease with low levels of disability and high levels of mortality [24].

The current study uses the following model specification:

- No-frills (i.e. no age-weighting and no discounting)
- Local life-expectancy (LE)
- Global burden of diseases 2010 disability weights

The CEA studies listed in Table 8 used the following models:

- Bachmann, 2009 (Zambia): Age weighting and discounting, local LE
- Wilford et al., 2011 (Malawi): Age weighting and discounting, local LE
- Puett et al., 2012 (Bangladesh): Age weighting and discounting, local LE
- Frankel et al., 2015 (Nigeria): Age weighting and discounting, local LE

These studies used the following costs-base:

- Bachmann, 2009 (Zambia): Institutional costs only

- Wilford et al., 2011 (Malawi): Institutional costs only
- Puett et al., 2012 (Bangladesh): Institutional and societal costs
- Frankel et al., 2015 (Nigeria): Institutional and societal costs

We expect the ratio of DALYs between a CEA using age-weighting and discounting and a CEA using the 'No frills' approach to be about 0.5 [28]. Applying this to the cost per DALY averted results show in Table 8 gives:

- Bachmann, 2009 (Zambia): Drops from $53 to $27
- Wilford et al., 2011 (Malawi): Drops from $42 to $21
- Puett et al., 2012 (Bangladesh): Drops from $26 to $13
- Frankel et al., 2015 (Nigeria): Drops from $30 to $15

CMAM programs are usually designed to minimize societal costs. In this study we found societal costs to be about 6% of total costs. Adjusting for this give:

- Bachmann, 2009 (Zambia): Increase from $27 to $29
- Wilford et al., 2011 (Malawi): Increased from $21 to $22

The adjusted (i.e. for DALY calculation model and to standardize the cost-base) cost per DALY averted becomes:

- Bachmann, 2009 (Zambia): $29
- Wilford et al., 2011 (Malawi): $22
- Puett et al., 2012 (Bangladesh): $13
- Frankel et al., 2015 (Nigeria): $15

CEA studies tend to use the US dollar as a benchmark currency. The value of a US dollar changes over time. It is possible to account for inflation using local consumer price index (CPI). This adjustment does not, however, account for place to place variation in the purchasing power of US dollars. A crude measure of relative wealth is gross domestic product (GDP) per-capita. It is possible to present results as the proportion of GDP per capita needed to avert a DALY. The World Bank publishes GDP time series and these enable the use the local (i.e. in time and space) GDP per capita to calculate the proportion of GDP per capita needed to avert one DALY. The adjusted outcomes are presented in Table 9.

Table 9. Adjusted cost per DALY averted from other studies

Country	Study year	GDP per capita (year)[a]	Cost per DALY averted[b]	Proportion of GDP per capita required to avert one DALY
Ethiopia	2019	$772 (2018)	$21.58	0.0280
			$10.75	0.0139
Niger	2018	$378 (2017)	$26	0.0694
Nigeria	2014	$3222 (2014)	$15	0.0047
Bangladesh	2009	$681 (2009)	$13	0.0191
Malawi	2007	$320 (2007)	$22	0.0688
Zambia	2008	$1369 (2008)	$29	0.0212

[a]World Bank data for 'GDP per capita (current US$)'

[b]Adjusted for DALY calculation model and to standardize the costs-base (see text)

It is common to use standard (threshold) values. Two standards are commonly used:

- **A single fixed standard for cost per DALY averted**: Interventions achieving a cost per DALY averted of less than US$100 at the time of analysis are classified as being very cost-effective [31]. The cost per DALY averted achieved by the current CMAM/Surge program was US$21.58. This program would, therefore, be classified as being very cost-effective.
- **Variable standard per DALY averted**: The most commonly-used standard in the public health nutrition field is one proposed by the WHO [32]. This compares the cost per DALY averted by an intervention with the per capita GDP of the country in which the intervention is implemented:
  - Highly cost-effective interventions avert a DALY for less than a country's GDP per capita.
  - Cost-effective interventions avert a DALY for between one and three times a country's GDP per capita.
  - Intervention that are not cost-effective avert a DALY for more than three times a country's GDP per capita.

The proportion of GDP required to avert one DALY by the current Surge program is 0.0280 (i.e. 2.80% of GDP). The Bati woreda CMAM Surge program can, therefore, be considered to be highly cost-effective.

Limitations

Limitations of CEAs overall are well documented [33]. A limitation specific to the current study should also be acknowledged. It appears that primary and secondary data were not collected from all health centers and health posts, as can be seen in Tables 3 and 4. Importantly, there were only one SC admission record in Bati, and three SC admission records in Dewa Chefa. As a result, variability in SC episodes (MUAC and length of stay) is likely to be underestimated, which will lead to narrower 95% confidence intervals on costs.

6. Conclusion

The Ethiopia CMAM Surge program as implemented in Bati woreda appears to be a very cost-effective strategy. The cost-effectiveness of the CMAM services, including CMAM Surge within the 32 OTP and 2 SC sites is still acceptable in relation to global benchmarks/standards and in comparison to CMAM programs without CMAM Surge.

7. Annexes

7.1. Annex A: Data collection tools

7.2. Annexes B: Data analysis methods

7.3. Annexes C: Operations between triangular fuzzy numbers

References Cited

i. Bobadilla JL, Cowley P, Musgrove P, Saxenian H. 1994. Design, content and financing of an essential national package of health services. Bulletin of the World Health Organization, 72(4): 653-662.

ii. Commission on Macroeconomics and Health. 2001. Macroeconomics and health: Investing in health for economic development. Geneva: WHO

3. UNICEF. 2013. Evaluation of Community Management of Acute Malnutrition (CMAM) - Global Synthesis Report. New York

4. Rogers E, Martínez K, Alvarez Morán JL et al. 2018. Cost-effectiveness of the treatment of uncomplicated severe acute malnutrition by community health workers compared to ttreatment provided at an outpatient facility in rural Mali. Human Resources for Health 16:12

5. Puett C, Sadler K, Alderman et al. 2013. Cost-effectiveness of the community-based management of severe acute malnutrition by community health workers in southern Bangladesh. Health Policy and Planning 28:386–399

6. Frankel S, Roland M, Makinen M. 2015. Costs, Cost-Effectiveness, and Financial Sustainability of Community-based Management of Acute Malnutrition in Northern Nigeria. Results for Development Institute

7. Concern Worldwide. 2015a. Concern Worldwide's Learning from 15 years of CMAM Programming.

8. Concern Worldwide. 2015b. Taking Stock: Concern Worldwide's 15 Year Contribution to CMAM.

9. Concern Worldwide. 2016a. What Have We Learned? Key Lessons From 20 Years of Programming in Ethiopia.

10. Concern Worldwide. 2017. The CMAM Surge Approach: An introduction and learning to date.

11. Concern Worldwide. 2019. The CMAM Surge Approach Summary Brief. Concern Worldwide, June 2019.

12. Centre for Humanitarian Change (CHC). 2015. Independent Evaluation of The CMAM Model Surge Pilot. Nairobi, Kenya.

13. Muwaga BK. 2016. Surge Programme: Review for Karamoja. Consultancy Report submitted to Concern Worldwide Uganda.

14. Concern Worldwide. 2016. CMAM Surge Approach Value for Money framework.

15. Briend A, Zimicki S. 1986. Validation of arm circumference as an indicator of risk of death in one to four year old children, Nutr Res 6:249-261

16. Briend A, Wojtyniak B, Rowland MGM. 1987. Arm circumference and other factors in children at high risk of death in rural Bangladesh, Lancet 26:725-727

17. Vella V, Tomkins A, Ndiku J, Marshal T, Cortinovis I. 1994. Anthropometry as a predictor for mortality among Ugandan children allowing for socio-economic status, Eur J Clin Nutr 48:189–197

18. Pelletier DL, Frongillo EA, Habicht JP. 1993. Epidemiologic evidence for a potentiating effect of malnutrition on child mortality, American Journal of Public Health 83:1130-1133

19. https://data.worldbank.org/indicator/SP.DYN.LE00.IN?locations=ET

20. Briend A, Zimicki S. 1986. Validation of arm circumference as an indicator of risk of death in one to four year old children, Nutr Res 6:249-261

21. Briend A, Wojtyniak B, Rowland MGM. 1987. Arm circumference and other factors in children at high risk of death in rural Bangladesh, Lancet 26:725-727

22. Vella V, Tomkins A, Ndiku J, Marshal T, Cortinovis I. 1994. Anthropometry as a predictor for mortality among Ugandan children allowing for socio-economic status, Eur J Clin Nutr 48:189–197

23. Pelletier DL, Frongillo EA, Habicht JP. 1993. Epidemiologic evidence for a potentiating effect of malnutrition on child mortality, American Journal of Public Health 83:1130-1133

24. WHO. 2013. WHO methods and data sources for global burden of disease estimates 2000-2011, Department of Health Statistics and Information Systems, World Health Organisation, Geneva, Switzerland, 2013

25. Kaufmann A, Gupta MN. 1985. Introduction to fuzzy arithmetic: Theory and applications, Van Nostrand Reinhold Co., New York, USA.

26. Forbes C, Evans N, Hastings N, Peacock B. 2011. Statistical Distributions. Fourth Edition, John Wiley and Sons, Hoboken, NJ USA.

27. Fotso JC, Myatt M. 2019. Cost Effectiveness Analysis of the Community-based Management of Acute Malnutrition (CMAM) Surge Approach in Niger. 2019

28. Wilford R, Golden K, Walker DG. 2012. Cost-effectiveness of community-based management of acute malnutrition in Malawi. Health Policy and Planning 27:127–137

29. Bachmann MO. 2013. Cost effectiveness of community-based therapeutic care for children with severe acute malnutrition in Zambia: decision tree model. Cost effectiveness and Resource Allocation, 7: 2

30. Puett, Bulti and Myatt. 2019. Disability-adjusted life years for severe acute malnutrition: implications of alternative model specifications. Public Health Nutrition, 1-9.

31. Bobadilla JL, Cowley P, Musgrove P, Saxenian H. 1994. Design, content and financing of an essential national package of health services. Bulletin of the World Health Organization, 72(4): 653-662.

32. Commission on Macroeconomics and Health. 2001. Macroeconomics and health: Investing in health for economic development. Geneva: WHO

33. Fiedler JL, Puett C. 2015. Micronutrient program costs: Sources of variations and noncomparabilities. *Food and Nutrition Bulletin, 36(1): 43-56*

Appendix A1: Woreda Level – Tool #1

CEA of CMAM SURGE Approach in Ethiopia
Nutrition Focal Point at Woreda Questionnaire

ID	**Region:** Amhara **Woreda** ☐1 Bati ☐2 Dewa Chefa	
1	Date (dd/mm/yy) – Western Calendar	____/____/____
2	Start time (use 24-hr clock) – Western Time	____: ____

Hello, my name is [NAME]. I represent EVIHDAF, an Evaluation organization that has been commissioned by Concern to conduct a study on the costs associated with the CMAM program here in Ethiopia. The results of the study will be used to improve the quality of the CMAM program in this woreda.

I am going to ask you a few questions about the CMAM program in this woreda. The topics I'd like to cover include: 1) Time spent on various CMAM activities; 2) Costs related to supervision and community visits; 3) Logistics and supply delivery costs; and 4) Costs associated with reporting CMAM statistics.

3	Respondent's name: _____
4	Sex: ☐1 Male ☐2 Female
5	Respondent's email address:

CMAM Human Resources - WoHO

We would like to establish the level of effort of staff working on CMAM activities. I am going to ask you some questions about all staff who perform CMAM activities, namely, [LIST OF CMAM ACTIVITIES FOR WOREDA LEVEL].

Have I missed any activities? If Yes, ascertain if the activities are indeed part of CMAM and update the list.

	Staff Name, Position	**Grade level**	**Number of years at present grade**	**Number of hours per week, on average, spent on CMAM**
6	_____, Nutrition FP			
7				
8				

	Staff Name, Position	Grade level	Number of years at present grade	Number of <u>hours per week</u>, on average, <u>spent on CMAM</u>
9				
10				
11				
12				
13				
14				

Supervision & Community Visits, Mobilization and Sensitization – Woreda level

We'd like to discuss the costs of supervision or community visits undertaken by the Woreda Health Office.

16	<u>In the last three months</u>, how many CMAM supervision/community visits have taken place?	|__|__|	
17	Let's focus now on the <u>last visit</u>. We'd like to know the total costs for <u>the entire period</u> and for all the staff involved, and whether the costs were reimbursed (e.g. by Concern or woreda). Staff costs are excluded.		
		Total cost	Reimbursed?
a	Transportation (car/taxi, fuel, driver …)	|__|__|__|	☐0 No ☐1 Yes
b	Accommodation, per diem, food, drink and related	|__|__|__|	☐0 No ☐1 Yes
c	Communications and related	|__|__|__|	☐0 No ☐1 Yes
d	Other [Specify] _____	|__|__|__|	☐0 No ☐1 Yes

CMAM Supply Delivery Costs – Woreda level

In this section, we'd like to discuss the logistics and delivery costs to bring CMAM consumables such as RUTF, drugs, vitamin A, therapeutic milks and related items from a higher level to this woreda, and to deliver these consumables to Health centers/posts. Staff costs are excluded.

18	Who pays for the delivery costs to bring CMAM consumables from a higher level to this woreda?	☐1 This WoHO ☐2 Higher level → **20**
19	<u>In last 3 months</u>, what has been the <u>average monthly</u> cost to bring CMAM consumables from a higher level to this woreda?	|__|__|__|__|

20	Who pays for the delivery costs to deliver these CMAM consumables to health centers/posts?	□1 This WoHO □2 Higher level → **22** □3 Concern → **22**
21	In last 3 months, what has been the average monthly cost to deliver these CMAM consumables to health centers/posts?	|__|__|__|__|

CMAM-Related Health Management Information System (HMIS) Costs

I am now going to ask you some questions about CMAM-related HMIS costs. Please provide the amounts this facility has spent in the last 30 days on collecting and transferring CMAM information, including transport, media and telephone costs. Also indicate whether the costs were reimbursed (e.g. by Concern or region). Staff costs are excluded.

		Cost in last 30 days	Reimbursed?
22	Data collection (transport, media, telephone …)	|__|__|__|__|	□0 No □1 Yes
23	Data transmission (transport, media, telephone …)	|__|__|__|__|	□0 No □1 Yes

24	End time (use 24-hr clock) – Western Time	_____**:**_____

Thank you for your answers! Do you have any questions for me?

Name and Signature of the *Interviewer* _____

Appendix A2: Health Center (HC)/Health Post (HP) – Tool #2

CEA of CMAM SURGE Approach in Ethiopia
In Charge at Health Center/Post Questionnaire

ID	**Region:** Amhara **Woreda** ☐1 Bati ☐2 Dewa Chefa **Health Center:** _____ Code: |__| **Health Post:** _____ Code: |__|	
1	Date (dd/mm/yy) – Western Calendar	___/___/___
2	Start time (use 24-hr clock) – Western Time	___: ___

Hello, my name is [NAME]. I represent EVIHDAF, an Evaluation organization that has been commissioned by Concern to conduct a study on the costs associated with the CMAM program here in Ethiopia. The results of the study will be used to improve the quality of the CMAM program in your community.

I am going to ask you a few questions about the CMAM program in this Health Center/Post. The topics I'd like to cover include: 1) Time spent on various CMAM activities; 2) Costs related to supervision and community visits; 3) Logistics and supply delivery costs; and 4) Costs associated with reporting CMAM statistics.

3	Respondent's name: _____
4	Sex: ☐1 Male ☐2 Female
5	Respondent's email address:

CMAM Human Resources

We would like to establish the level of effort of staff working on CMAM activities. I am going to ask you some questions about <u>all staff who perform CMAM activities</u>, namely, [LIST OF CMAM ACTIVITIES].

Have I missed any activities? If Yes, ascertain if the activities are indeed part of CMAM and update the list.

	Staff Name, Position	**Grade level**	**Number of years at present grade**	**Number of <u>hours per week</u>, on average, <u>spent on CMAM</u>**
6	_____, In Charge			
7				

	Staff Name, Position	Grade level	Number of years at present grade	Number of hours per week, on average, spent on CMAM
8				
9				
10				
11				
12				
13				
14				

Supervision & Community Visits, Mobilization and Sensitization

We'd like to discuss the costs of supervision or community visits undertaken by the Health Center/Post.

16	In the last three months, how many CMAM supervision/community visits have taken place?	|__|__|	
17	Let's focus now on the last visit. We'd like to know the total costs for the entire period and for all the staff involved, and whether the costs were reimbursed (e.g. by Concern or woreda). Staff costs are excluded.		
		Total cost	Reimbursed?
a	Transportation (car/taxi, fuel, driver …)	|__|__|__|	☐0 No ☐1 Yes
b	Accommodation, per diem, food, drink and related	|__|__|__|	☐0 No ☐1 Yes
c	Communications and related	|__|__|__|	☐0 No ☐1 Yes
d	Other [Specify] _____	|__|__|__|	☐0 No ☐1 Yes

CMAM Supply Delivery Costs

In this section, we'd like to discuss the logistics and delivery costs to bring CMAM consumables such as RUTF, drugs, vitamin A, therapeutic milks and related items from a higher level to this Health Center/Post, and to deliver these consumables to a lower level. Staff costs are excluded.

18	Who pays for the delivery costs to bring CMAM consumables from a higher level to this facility?	☐1 This HC/HP ☐2 Higher level → **20**

19	What is the <u>average monthly</u> delivery costs to bring CMAM consumables from a higher level to this facility?	|__|__|__|__|
20	**<u>For HCs only</u>**: Who pays for the delivery costs to deliver these CMAM consumables to a lower level (e.g. to HPs)?	□1 This HC
21	What is the <u>average monthly</u> delivery costs to deliver these CMAM consumables to a lower level?	|__|__|__|__|

CMAM-Related Health Management Information System (HMIS) Costs

I am now going to ask you some questions about CMAM-related HMIS costs. Please provide the amounts this facility has spent <u>in the last 30 days</u> on collecting and transferring CMAM information, including transport, media and telephone costs. Also indicate whether the costs were reimbursed (e.g. by Concern or woreda). Staff costs are excluded.

		Cost in last 30 days	Reimbursed?
22	Data collection (transport, media, telephone …)	|__|__|__|__|	□0 No □1 Yes
23	Data transmission (transport, media, telephone …)	|__|__|__|__|	□0 No □1 Yes
24	End time (use 24-hr clock) – Western Time	_____:_____	

Thank you for your answers! Do you have any questions for me?

Name and Signature of the *Interviewer* _____

Appendix A3: Community-based Volunteers (CVs) – Tool #3

CEA of CMAM SURGE Approach in Ethiopia

Community Volunteer Questionnaire

ID	**Region:** Amhara **Woreda** ☐1 Bati ☐2 Dewa Chefa **Health Center:** _____ Code: |__| **Health Post:** _____ Code: |__|	
1	Date (dd/mm/yy) – Western Calendar	___/___/___
2	Start time (use 24-hr clock) – Western Time	___: ___

Hello, my name is [NAME]. I represent EVIHDAF, an Evaluation organization that has been commissioned by Concern to conduct a study on the costs associated with the CMAM program here in Ethiopia. The results of the study will be used to improve the quality of the CMAM program in your community.

I am going to ask you a few questions about the work you do as a community volunteer, focusing on your CMAM activities in the previous week (last seven days).

3	Respondent's name: _____		
4	Sex: ☐1 Male ☐2 Female		
5	In the last 7 days, how much time did you spend each day on ALL CMAM activities, both in the communities you serve and at Health Posts? To conduct these activities, how much did you spend each day on transport, including trips to and from the communities you serve, and to and from Health Posts?		
		Total time spent	Total transport cost
5a	Yesterday [NAME OF DAY]	Hour: |__|__| Minute: |__|__|	|__|__|__|
5b	Day before [NAME OF DAY]	Hour: |__|__| Minute: |__|__|	|__|__|__|
5c	Day before [NAME OF DAY]	Hour: |__|__| Minute: |__|__|	|__|__|__|
5d	Day before [NAME OF DAY]	Hour: |__|__| Minute: |__|__|	|__|__|__|
5e	Day before [NAME OF DAY]	Hour: |__|__| Minute: |__|__|	|__|__|__|
5f	Day before [NAME OF DAY]	Hour: |__|__| Minute: |__|__|	|__|__|__|
5g	Day before [NAME OF DAY]	Hour: |__|__| Minute: |__|__|	|__|__|__|
6	In the last 12 months, have you attended any training related to CMAM program?		☐0 No → PROBE ☐1 Yes
7	How many training days in total, including travels, did you have in the last 12 months?		Days: |__|__|
8	End time (use 24-hr clock) – Western Time		_____:_____

Thank you for your answers! **Do you have any questions for me?**
Name and Signature of the ***Interviewer*** _____

Appendix A4a: Caregivers at OTP – Tool 4a

CEA of CMAM SURGE Approach in Ethiopia

Caregivers at Health Facility (OTP) Questionnaire

ID	**Region:** Amhara **Woreda** ☐1 Bati ☐2 Dewa Chefa **Health Center:** _____ Code: |__| **Health Post:** _____ Code: |__|	
1	Date (dd/mm/yy) – Western Calendar	____/_____/_____
2	Start time (use 24-hr clock) – Western Time	____: ____

Hello, my name is [NAME]. I represent EVIHDAF, an Evaluation organization that has been commissioned by Concern to conduct a study on the costs associated with the accessing care for your child suffering from malnutrition. The results of the study will be used to improve the quality of care in your community. I am going to ask you a few questions about this visit for the treatment of your child at this health facility.

3	How long did you spend in the health facility today, from the time you arrived to the time you received all services, RUTF, drugs, etc. and could leave?	Hours: |__|__| Minutes: |__|__|
4	How long was the trip from your house to arrival at the health center?	Hours: |__|__| Minutes: |__|__|
5	Did you or your household members pay anything for, or during your trip from your home to the health facility, or while waiting to be seen today? This may include transport costs, water, food, etc.	☐0 No → PROBE ☐1 Yes
6	**If Yes**, how much money in Birr was spent for your trip from home to arrival at the health center today?	|__|__||__|
7	Did you or your household members pay for any health care services received at this facility today for SAM treatment?	☐0 No → PROBE ☐1 Yes
8	**If Yes**, how much in Birr, did you spend on these services?	Consultation fees |__|__|__| Drugs |__|__|__| Lab tests |__|__|__| RUTF |__|__|__| _____ |__|__|__| _____ |__|__|__|
9	End time (use 24-hr clock) – Western Time	_____:_____

Thank you for your answers! **Do you have any questions for me?**

Name and Signature of the ***Interviewer*** _____

Appendix A4b: Caregivers at SC – Tool #4b

CEA of CMAM SURGE Approach in Ethiopia

Caregivers at Stabilization Center (SC) Questionnaire

ID	**Region:** Amhara **Woreda** ☐1 Bati ☐2 Dewa Chefa **Health Center:** _____ Code: |__| **Health Post:** _____ Code: |__|	
1	Date (dd/mm/yy) – Western Calendar	____/____/____
2	Start time (use 24-hr clock) – Western Time	____: ____

Hello, my name is [NAME]. I represent EVIHDAF, an Evaluation organization that has been commissioned by Concern to conduct a study on the costs associated with the accessing care for your child suffering from malnutrition. The results of the study will be used to improve the quality of care in your community. I am going to ask you a few questions about your experience during the treatment of your child at this heath facility, and the expenses you and your household members have incurred since this time yesterday.

3	How long was the trip from your house to arrival at this SC?	Hours: |__|__| Minutes: |__|__|
4	Did you or your household members pay anything for, or during your trip from your home to this SC, or while waiting to be seen the day of arrival? This may include transport costs, water, food, etc.	☐0 No → PROBE ☐1 Yes
5	**If Yes**, how much money in Birr was spent on your trip from home to this SC?	|__|__||__|
6	Since this time yesterday, did you or your household members pay for any health care services received at this SC for your child's SAM treatment?	☐0 No → PROBE ☐1 Yes
7	**If Yes**, how much in Birr, did you spend since this time yesterday on these services?	Registration |__|__|__| Drugs |__|__|__| Bed rental |__|__|__| X-Rays |__|__|__| Lab tests |__|__|__| RUTF |__|__|__| _____ |__|__|__| _____ |__|__|__|
8	What is the approximate value of food, drinks and related items your and your child have consumed at this SC since this time yesterday?	|__|__|__| If None: --→ PROBE
9	End time (use 24-hr clock) – Western Time	_____:_____

Thank you for your answers! **Do you have any questions for me?**

Name and Signature of the ***Interviewer*** _____

Appendix A5a: Outpatient Episodes – OTP – Tool #5a

CEA of CMAM SURGE Approach in Ethiopia

OTP SAM Episode Data Form

ID	**Region:** Amhara **Woreda** ☐1 Bati ☐2 Dewa Chefa **Health Center:** _____ Code: |__| **Health Post:** _____ Code: |__|	
1	Date (dd/mm/yy) – Western Calendar	____/____/____
2	Start time (use 24-hr clock) – Western Time	____: ____

Hello, my name is [NAME]. I represent EVIHDAF, an Evaluation organization that has been commissioned by Concern to conduct a study on the costs associated with the CMAM program here in Ethiopia. The results of the study will be used to improve the quality of the CMAM program in this community.

I would like to retrieve routine CMAM data on date of admission and date of exit or discharge, age, weight and MUAC at admission, and attendance rate.

3	Facilitator's name & position: _____
4	Facilitator's phone number:

Age at admission (months)	MUAC at admission (mm)	Weight at admission (kg)	Date of admission (dd/mm/yy)	Date of exit/discharge (dd/mm/yy)	Number of weeks attended	Exit type (1=Cured; 2=Other)

IF ADDITIONAL ROWS ARE NEEDED, USE A SEPARATE SHEET.

8	Period of admission covered (dd/mm/yy)	/____/____/____/ to /____/____/____/
8	End time (use 24-hr clock) – Western Time	_____:_____

Name and Signature of the ***Data Collector*** _____

Appendix A5a: Inpatient Episodes – SC – Tool #5b

CEA of CMAM SURGE Approach in Ethiopia
Stabilization Center SAM Episode Data Form

ID	**Region:** Amhara **Woreda** ☐1 Bati ☐2 Dewa Chefa **Health Center:** _____ Code: |__| **Health Post:** _____ Code: |__|	
1	Date (dd/mm/yy) – Western Calendar	___/___/___
2	Start time (use 24-hr clock) – Western Time	___: ___

Hello, my name is [NAME]. I represent EVIHDAF, an Evaluation organization that has been commissioned by Concern to conduct a study on the costs associated with the CMAM program here in Ethiopia. The results of the study will be used to improve the quality of the CMAM program in this community.

I would like to retrieve routine CMAM data on age and MUAC at admission, and length of stay.

3	Facilitator's name & position: _____
4	Facilitator's phone number:

Age at admission (months)	MUAC at admission (mm)	Length of stay (days)	Age at admission (months)	MUAC at admission (mm)	Length of stay (days)

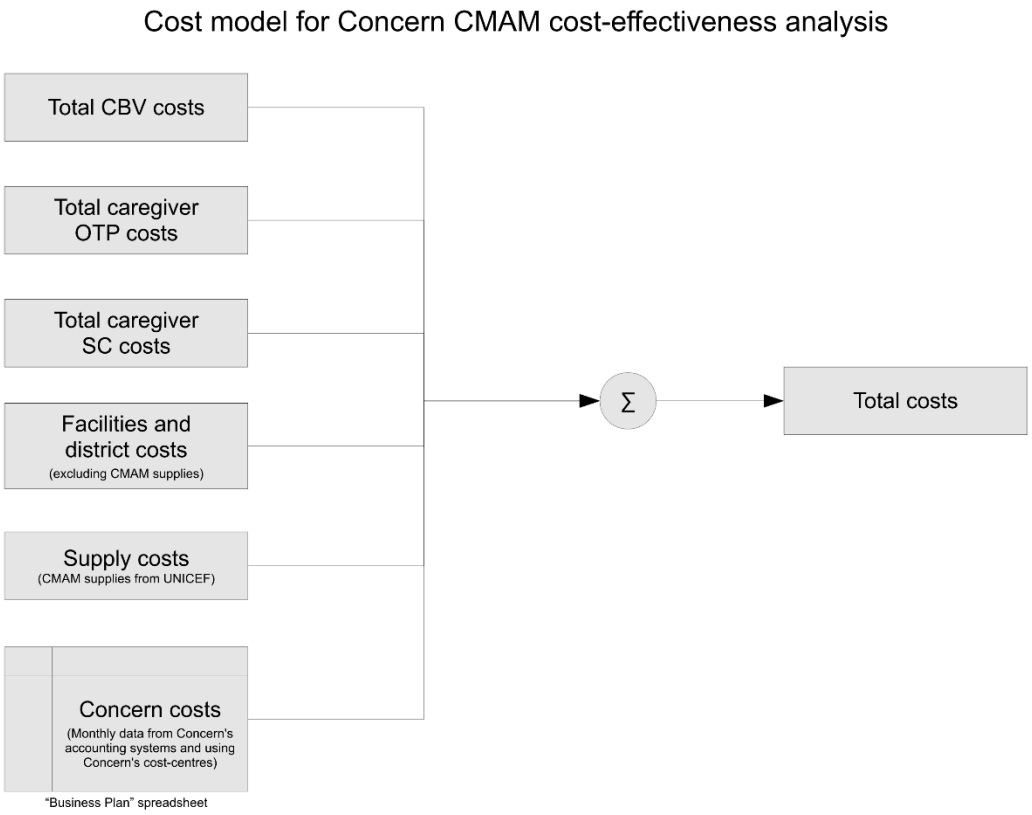
IF ADDITIONAL ROWS ARE NEEDED, USE A SEPARATE SHEET.

8	Period of admission covered (dd/mm/yy)	/___/___/___/ to /___/___/___/
8	End time (use 24-hr clock) – Western Time	___:___

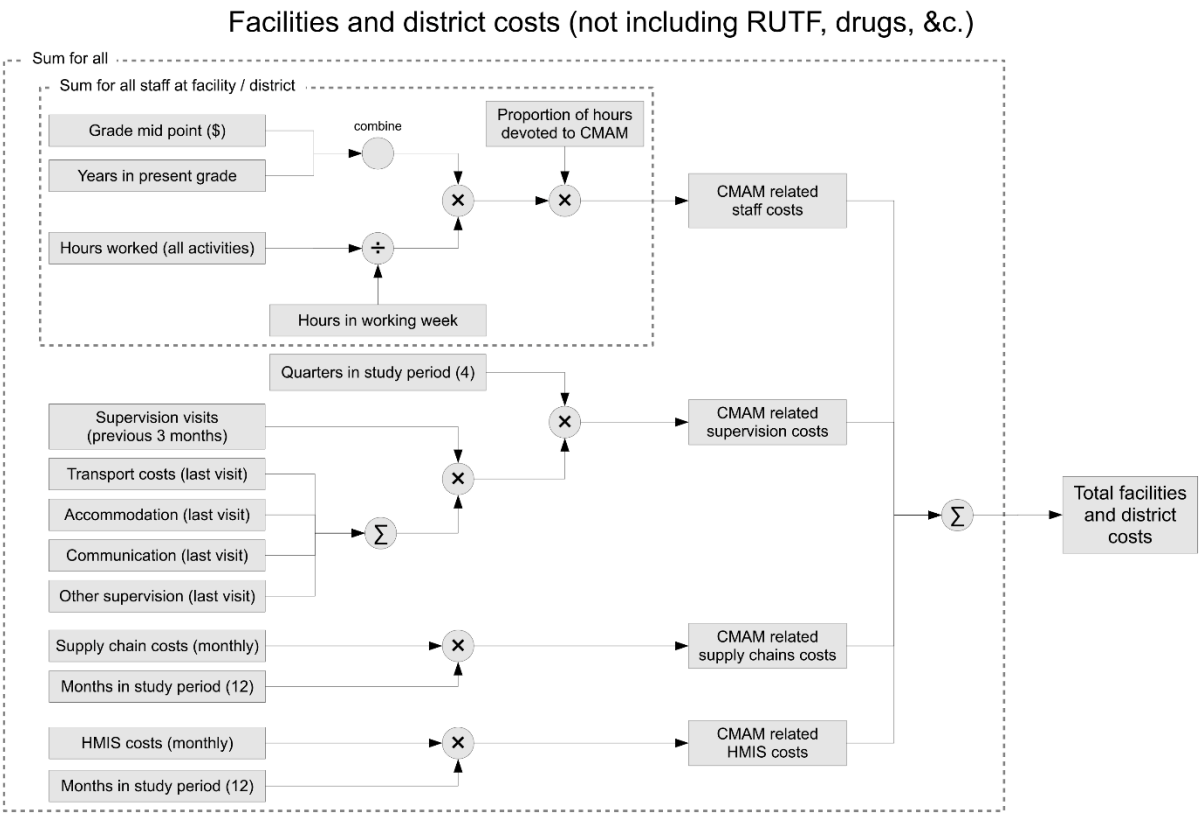
Name and Signature of the ***Data Collector*** _____

Annexes B

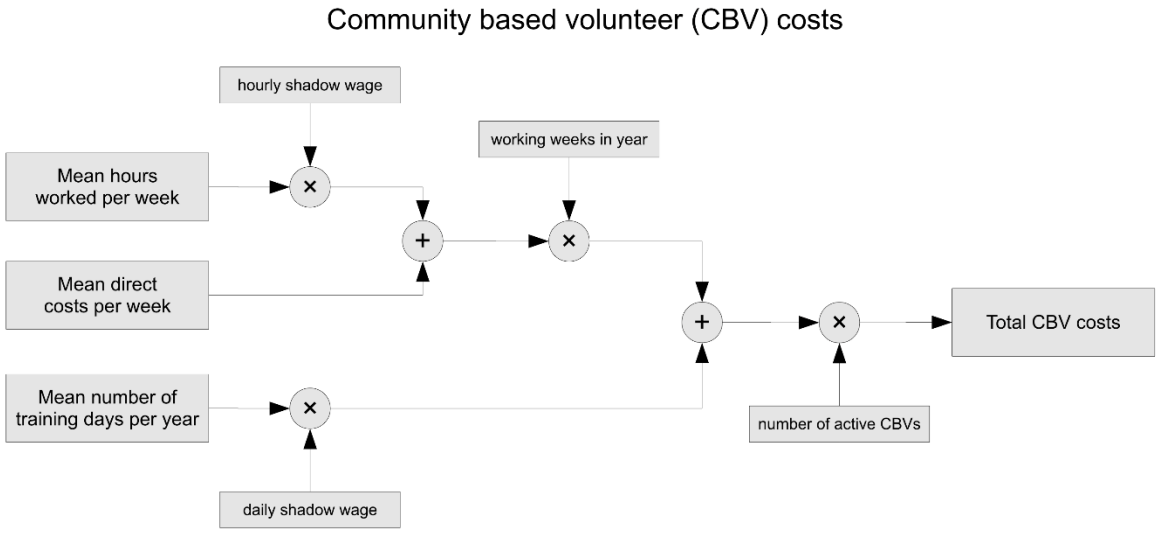
Appendix B1. Diagrammatical Presentation of Cost Centers



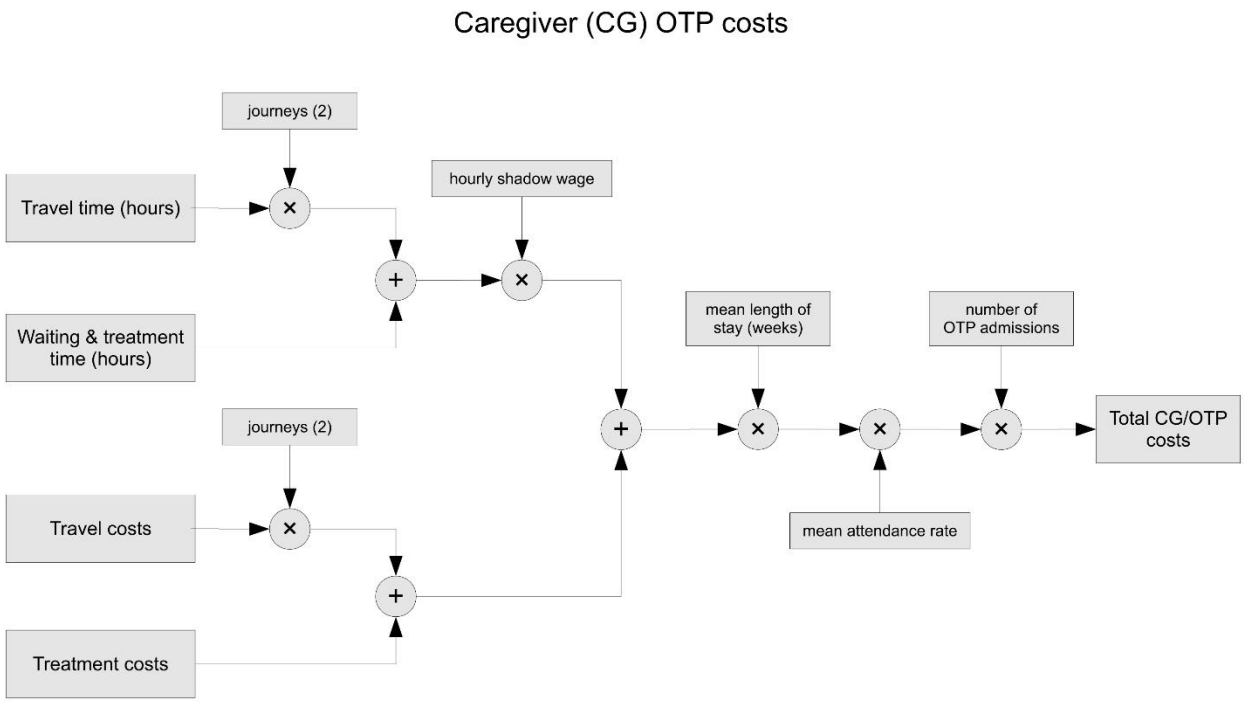
Annex B2: District and Health Center/Post Cost



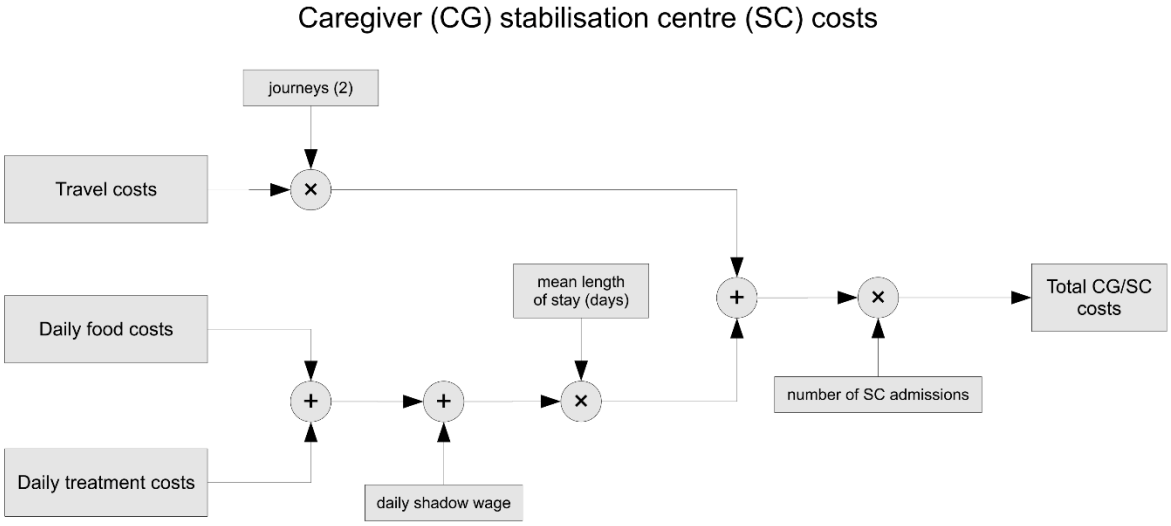
Annex B3: Community volunteer costs



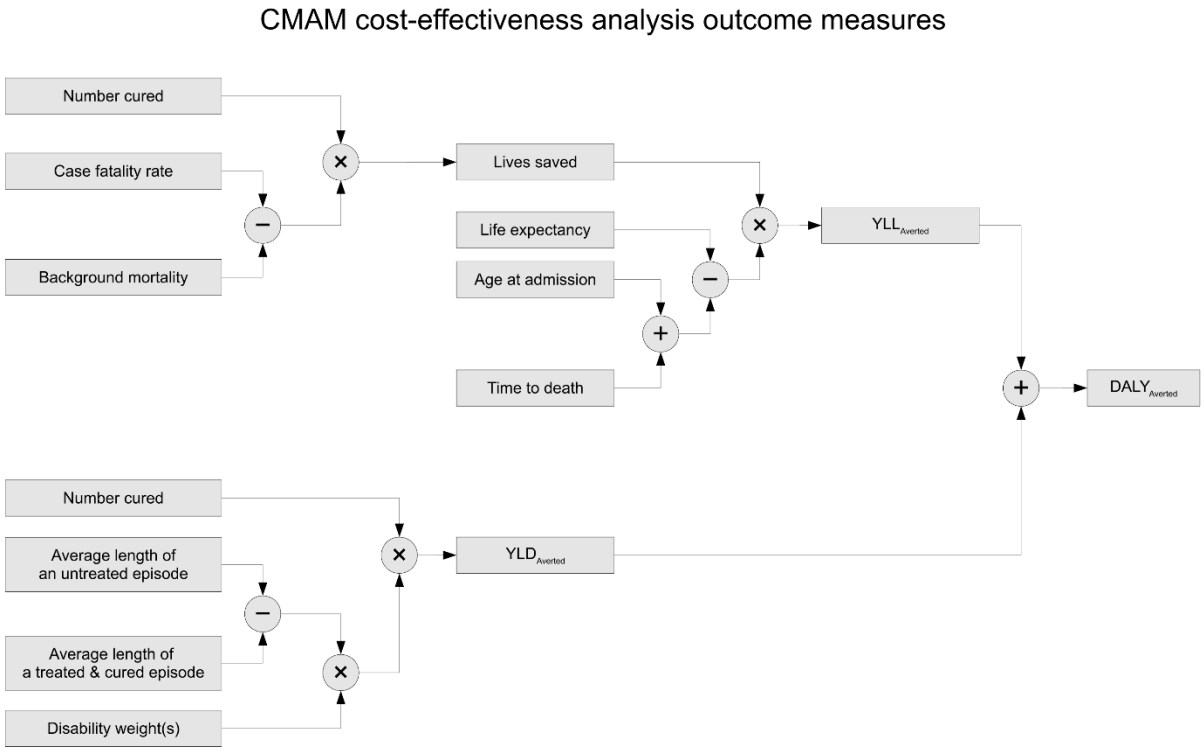
Annex B4a: Caregivers at OTP costs



Annex B4b: Caregivers at SC costs

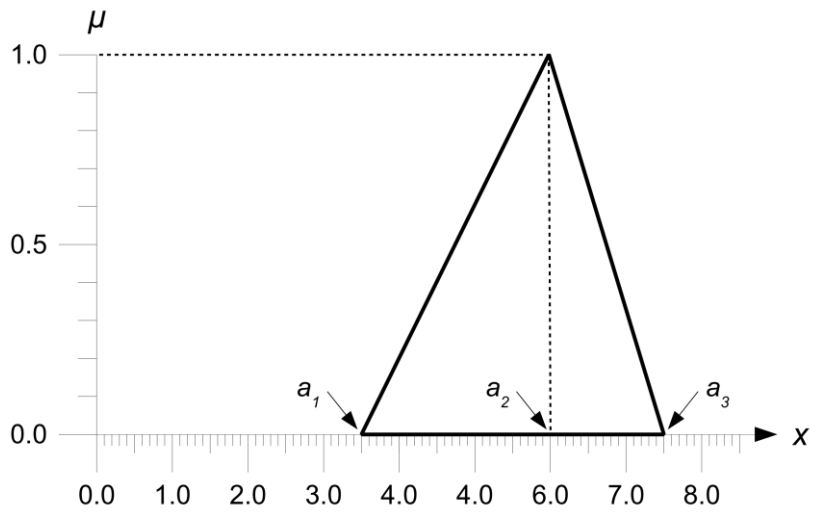


Annex B5. Diagrammatical Overview of DALYs Calculations



Annex C: Operations between triangular fuzzy numbers

A triangular fuzzy number consists of three "crisp" numbers which define the positions on the number line of the vertices of the triangular fuzzy number. For example:



This is represented using the triangular fuzzy number:

$$A = (a_1, a_2, a_3) = (lowest\ value, most\ likely\ value, highest\ value) = (3.5, 6.0, 7.5)$$

Probability is replaced by a measure of membership (μ) in the set of possible values.

Operations on triangular fuzzy numbers are performed using a mixture of simple arithmetic for the central values and interval arithmetic for the lowest and highest values. Given two triangular fuzzy numbers:

$$A = (3, 6, 8) \text{ and } B = (1, 2, 3)$$

then:

$$\begin{aligned} A + B &= (a_1 + b_1, a_2 + b_2, a_3 + b_3) \\ &= (3 + 1, 6 + 2, 8 + 3) \\ &= (4, 8, 11) \end{aligned}$$

$$\begin{aligned} A - B &= (a_1 - b_3, a_2 - b_2, a_3 - b_1) \\ &= (3 - 3, 6 - 2, 8 - 1) \\ &= (0, 4, 7) \end{aligned}$$

$$\begin{aligned} A \times B &= (a_1 \times b_1, a_2 \times b_2, a_3 \times b_3) \\ &= (3 \times 1, 6 \times 2, 8 \times 3) \\ &= (3, 12, 24) \end{aligned}$$

$$\begin{aligned} A \div B &= (a_1 \div b_3, a_2 \div b_2, a_3 \div b_1) \\ &= (3 \div 3, 6 \div 2, 8 \div 1) \\ &= (1, 3, 8) \end{aligned}$$

Operations involving constants (or non-fuzzy numbers) are simple. For example:

$$\begin{aligned} A + 12 &= (a_1 + 12, a_2 + 12, a_3 + 12) \\ &= (3 + 12, 6 + 12, 8 + 12) \\ &= (15, 18, 20) \end{aligned}$$

The approach is the same for all operations involving constants (or non-fuzzy numbers). For example:

$$\begin{aligned} A \div 12 &= (a_1 \div 12, a_2 \div 12, a_3 \div 12) \\ &= (3 \div 12, 6 \div 12, 8 \div 12) \\ &= (0.2500, 0.5000, 0.6667) \end{aligned}$$

Operations are a little more complicated when dealing with zero and / or negative numbers. In this case a minimum / maximum rule is used:

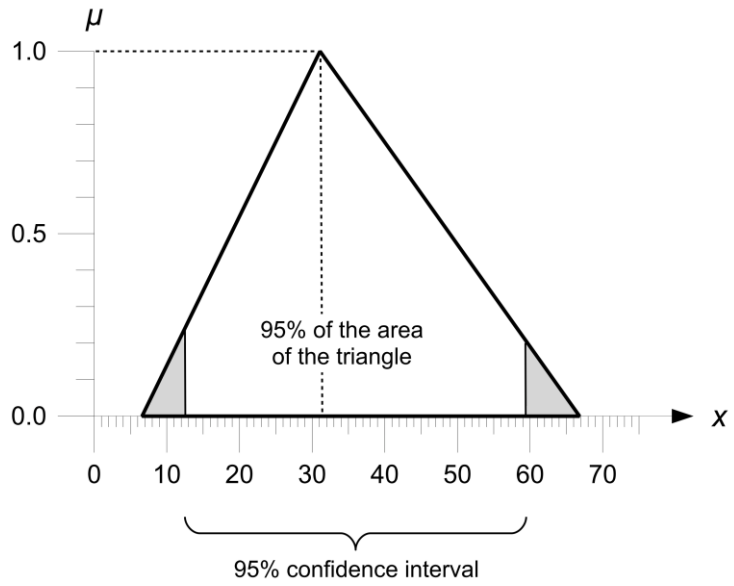
$$\begin{aligned} A \odot B = \min(a_1 \odot b_1, a_1 \odot b_3, a_3 \odot b_1, a_3 \odot b_3)\,, a_2 \\ \odot\, b_2, \max(a_1 \odot b_1, a_1 \odot b_3, a_3 \odot b_1, a_3 \odot b_3) \end{aligned}$$

where $\odot$ is the operation (i.e. addition, subtraction, multiplication, or division) required.

Confidence limits for a triangular fuzzy number

A triangular fuzzy number expresses the most likely value and the range of possible values for a quantity. We can think of the upper and lower limits of a triangular fuzzy number as an approximate 100% confidence interval since it should contain all, or nearly all, possible values of the quantity of interest. We usually want to present 95% confidence intervals.

The 95% CI contains the central 95% of the area of the triangle:



Given a triangular fuzzy number:

$$A = (a_1, a_2, a_3)$$

The point estimate is a_2.

The 95% confidence limits for a_2 is calculated as:

$$Lower\ confidence\ limit = a_1 + \sqrt{(a_3 - a_1)\ \times\ (a_2 - a_1)\ \times\ 0.025}$$

$$Upper\ confidence\ limit = a_3 - \sqrt{(a_3 - a_1)\ \times\ (a_3 - a_2)\ \times\ 0.025}$$

If (e.g.) we calculate $YLD_{Averted}$ using triangular fuzzy numbers and find:

$$YLD_{Averted} = (6.4, 31.1, 66.9)$$

then the 95% confidence limits on $YLD_{Averted}$ are:

$$Lower\ confidence\ limit = 6.4 + \sqrt{(66.9 - 6.4)\ \times\ (31.1 - 6.4)\ \times\ 0.025} = 12.5$$

$$Upper\ confidence\ limit = 66.6 - \sqrt{(66.9 - 6.4)\ \times\ (66.9 - 31.1)\ \times\ 0.025} = 59.5$$

We would report our findings as "$YLD_{Averted}$ = 31.1 (95% CI = 12.5 – 59.5)".