Technical Alliance

Costing Child Wasting Treatment Introduction to cost analysis and cost-effectiveness analysis for CMAM

Wednesday, 9 Nov 2022

GLOBAL NUTRITION CLUSTER
Technical Alliance

Webinar Series: Costing Child Wasting Treatment

Introduction to cost analysis and cost-effectiveness analysis for CMAM

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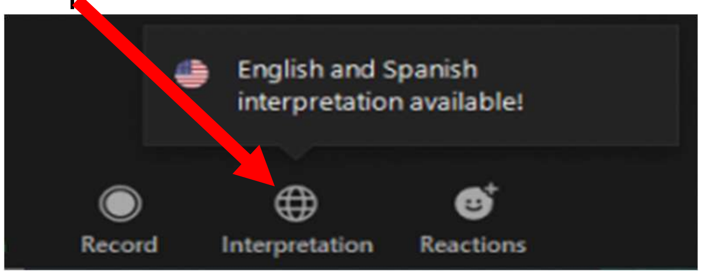

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Webinar Series: Costing Child Wasting Treatment

Introduction to cost analysis and cost-effectiveness analysis for CMAM

November 9, 2022 **3-4.30PM CET**

Webinar Working Group

Supporting Donors

***Note**: This webinar is made possible by the generous support of all of our donors, however, the contents are the responsibility of the GNC Technical Alliance and the individual presenters and do not necessarily reflect the views of these donors.*

Child wasting costing and cost-effectiveness working group

- Formed in 2021 as a sub-working group to Wasting GTWG:
  - Raise awareness on the importance and use of cost data for decision making relating to the treatment of wasting
  - And to increase availability and quality of costing data on wasting
  - Share information related to cost and cost-effectiveness of wasting treatment

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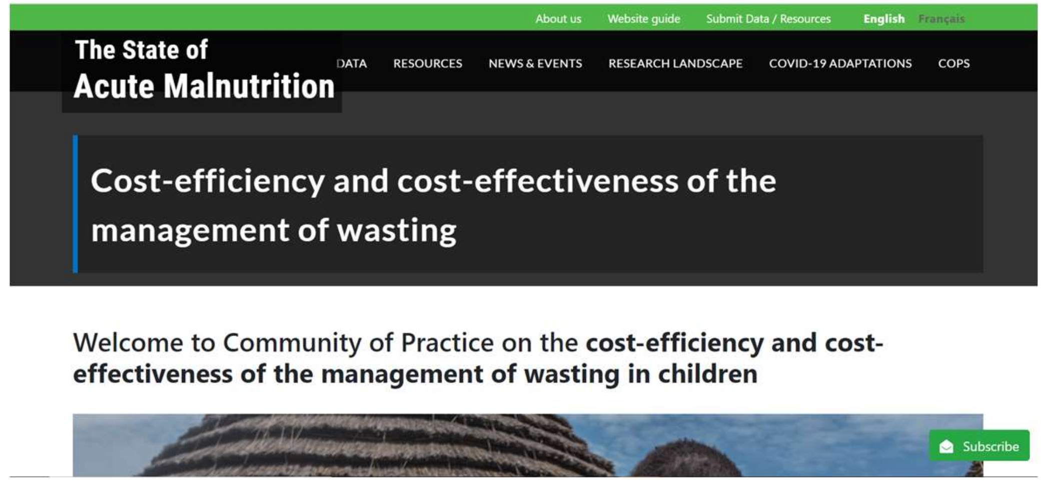
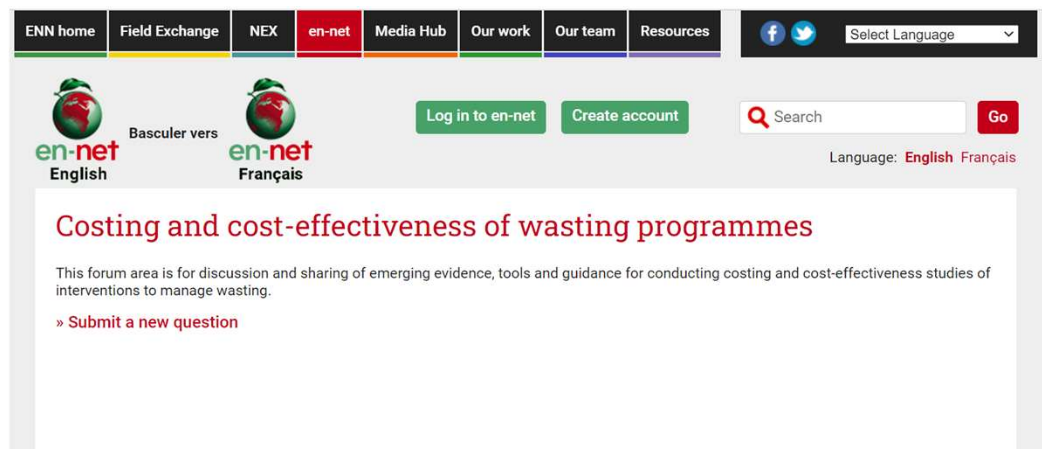
Webinar Series Objectives:

- Share basic instruction on costing and cost-effectiveness analysis for interventions to treat child wasting
- Disseminate the key resources
- Inform on the existence of working group on the costing wasting treatment





Webinar Agenda

- Introduction
- Presentation 1: Introduction to cost effectiveness
- Presentation 2: Costing module
- Presentation 3: Basic to DALYs module
- Presentation 4: Specific example of DALY's with CMAM programs
- Presentation 5: DALY's Uncertainty module
- Closing and Evaluation

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Today's Facilitators and Presenters

Emily Keane
Senior Nutrition Advisor
Save the Children

Bernardette Cichon
Senior Research Advisor
Action Against Hunger UK

Stacie Gobin
Team Lead, Value for Money
Save the Children

Chloe Puett
Independent consultant, Researcher
Stony Brook University - Public Health

Mark Myatt
Epidemiologist consultant
Brixton University
And
Technical Associate at the Emergency Nutrition Network

Introduction to cost analysis and cost-effectiveness analysis for CMAM

Chloe Puett, PhD
Independent Consultant
Stony Brook University, Public Health Program

Outline

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- Overview of cost-effectiveness for CMAM
- Costs module
- DALYs module
- Dealing with uncertainty

CEA of CMAM Handbook

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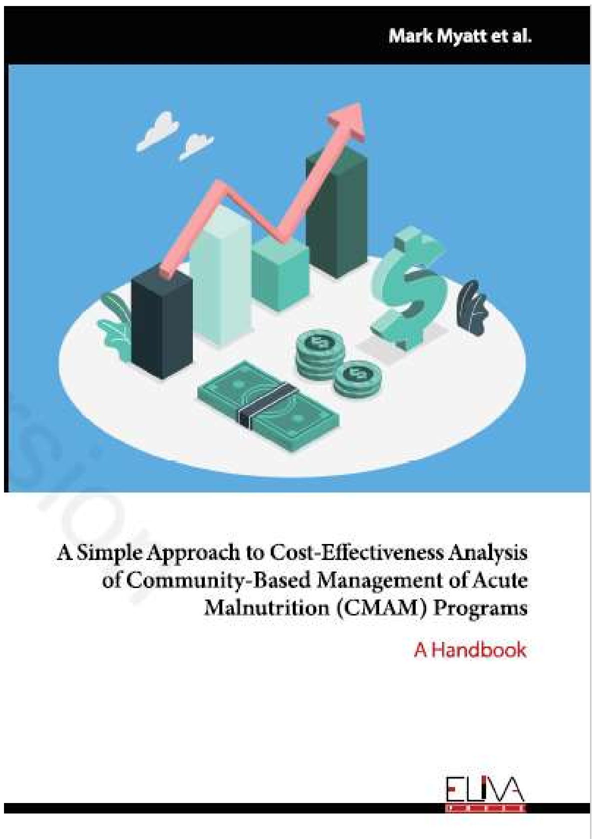
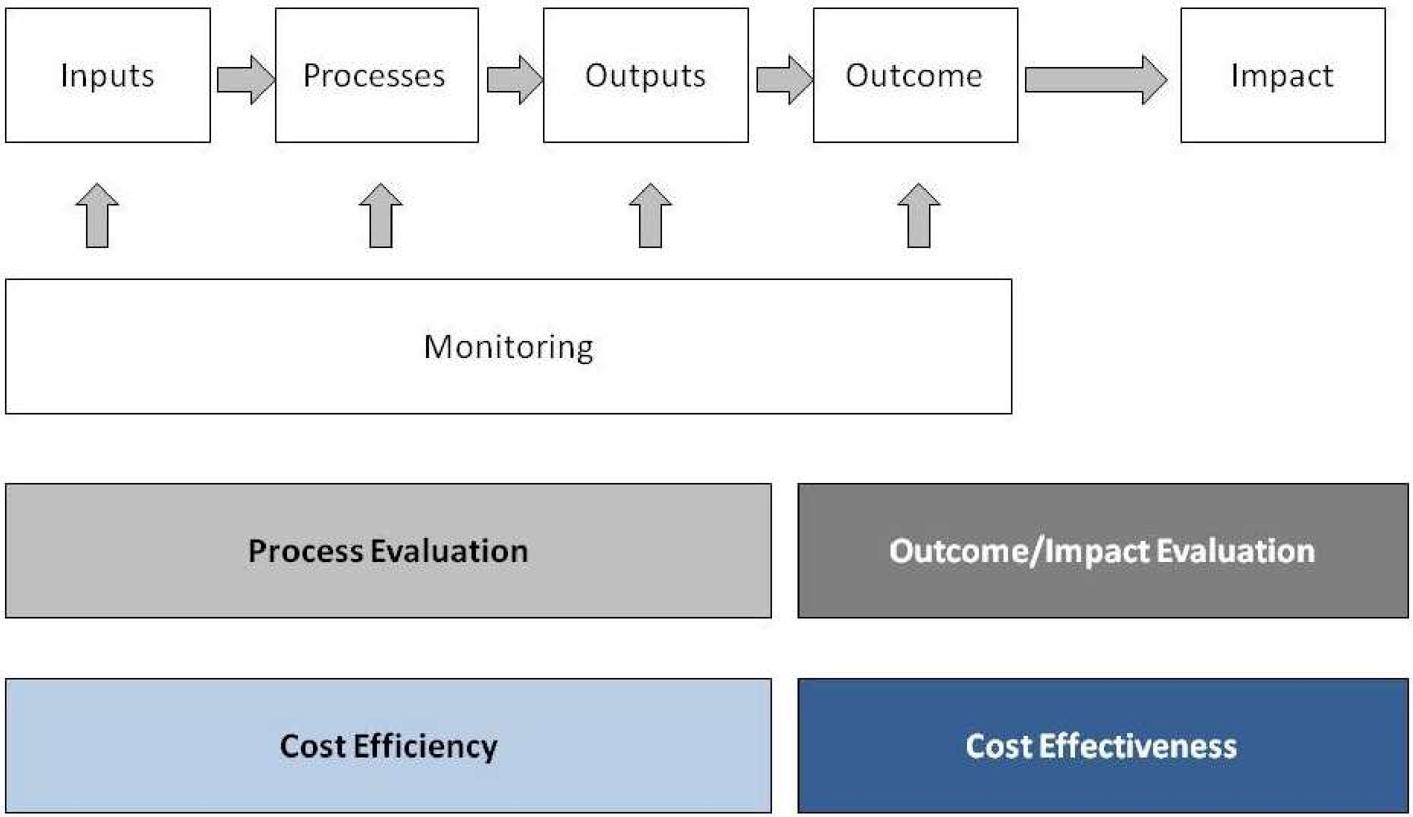


- Presentations draw from our recent handbook
- Instruction & considerations for cost-effectiveness analysis specifically for CMAM
- DALY calculations for preventing morbidity, mortality attributable to SAM
- Cost data collection templates for CMAM
- Applied examples of cost & CEA analyses of CMAM programs in different settings

Cost-effectiveness analysis overview

When to conduct CEA?



Types of economic evaluation

Method of Analysis	Cost	Effect
Cost-Efficiency	$	Output achieved: cost per child treated/enrolled *Example: compare resource use across programs*
Cost-Effectiveness	$	Disease-related outcome: cost per child recovered *Example: compare with other wasting programs*
Cost-Utility	$	General measure of death & disability: DALY, QALY *Example: compare w/ broader programs (other diseases)*
Benefit-Cost	$	$ *Example: compare program benefits ($) with costs*

Other analyses focus only on costs, the best method depends on specific objectives

CMAM outcome measures

- Cases treated
  - Not effectiveness measure, efficiency
  - Compare with other CMAM programs
- Cases recovered/cured
  - Compare with other CMAM programs
- Lives saved/deaths averted
  - Compare with any program preventing mortality
  - Requires use of “counterfactual” (informed guess, what would have happened without program)
- Disability-adjusted life years (DALYs)
  - Compare with programs addressing other diseases
  - Combines years of life lost (YLL) and years lived with disability (YLD)
  - Mark will discuss this more

Average C-E ratio (ACER)

Provider costs

- Salary & time use
- Medical supplies
- Therapeutic foods
- Rent & utilities

Participant costs

- Wage loss
- Transport
- Food
- Medicine & doctor fees

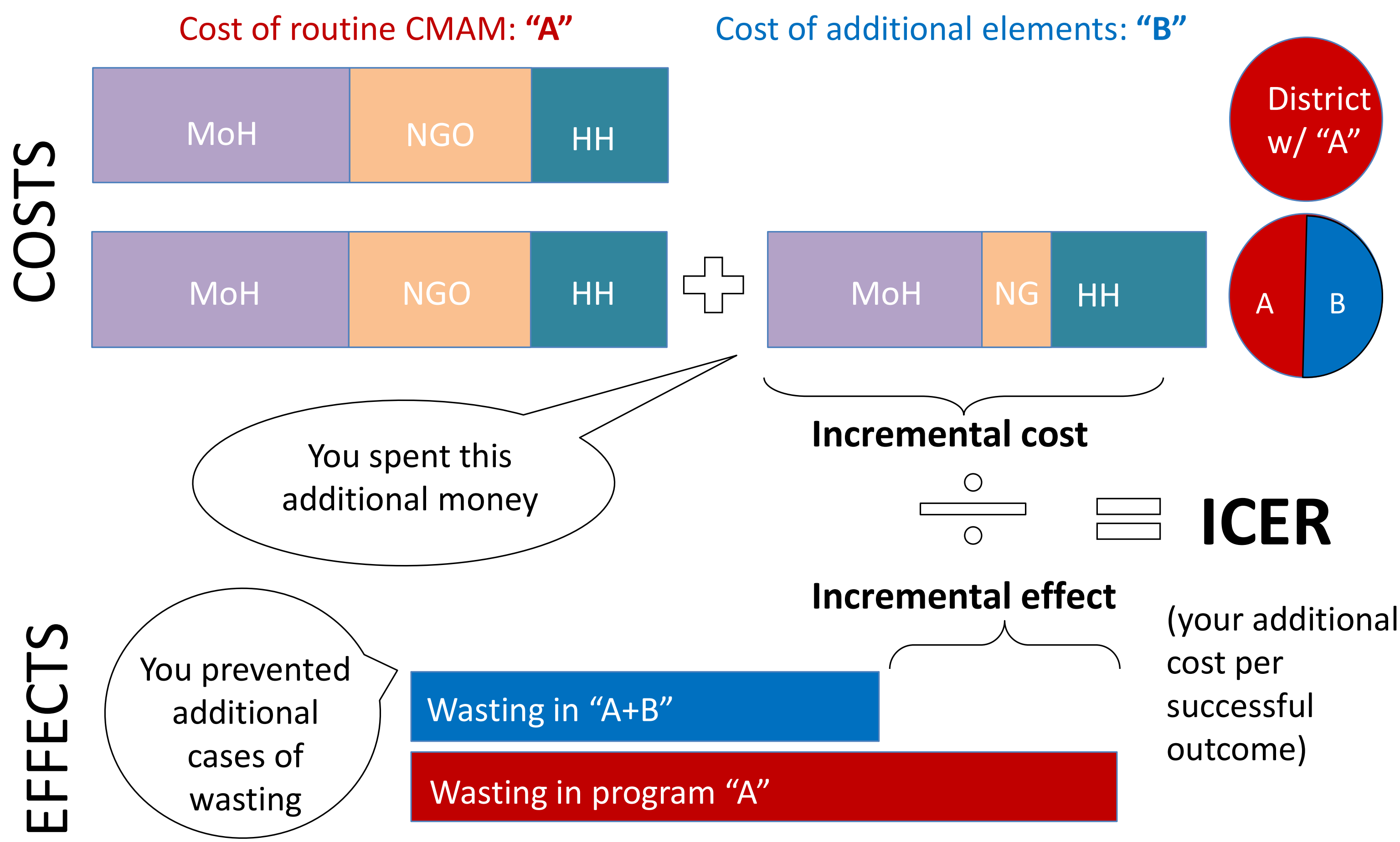
$$\frac{\text{Costs}}{\text{Effects}}$$

children recovered

children treated

DALYs averted

Incremental C-E ratio (ICER)



Costing module

Whose costs to include?

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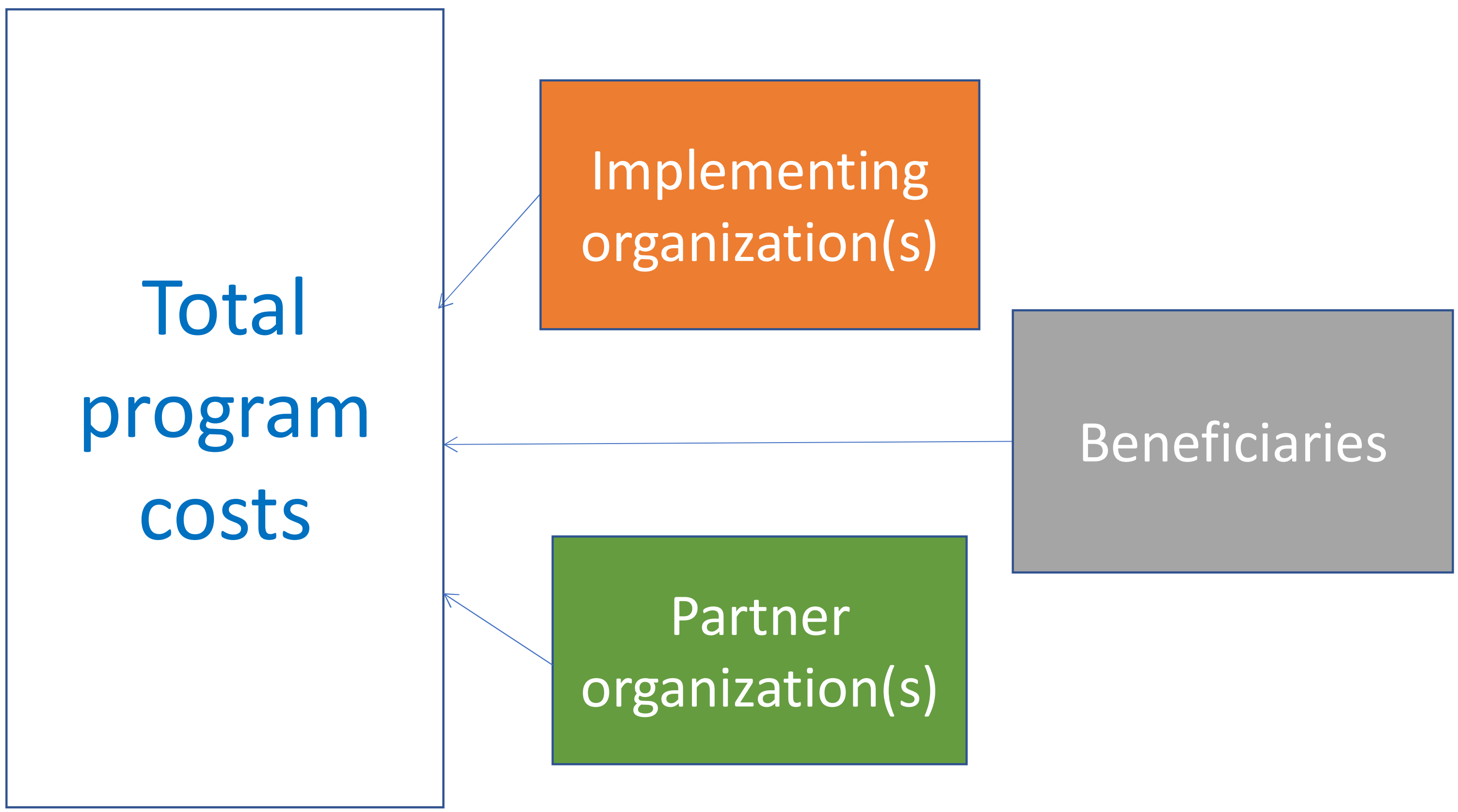
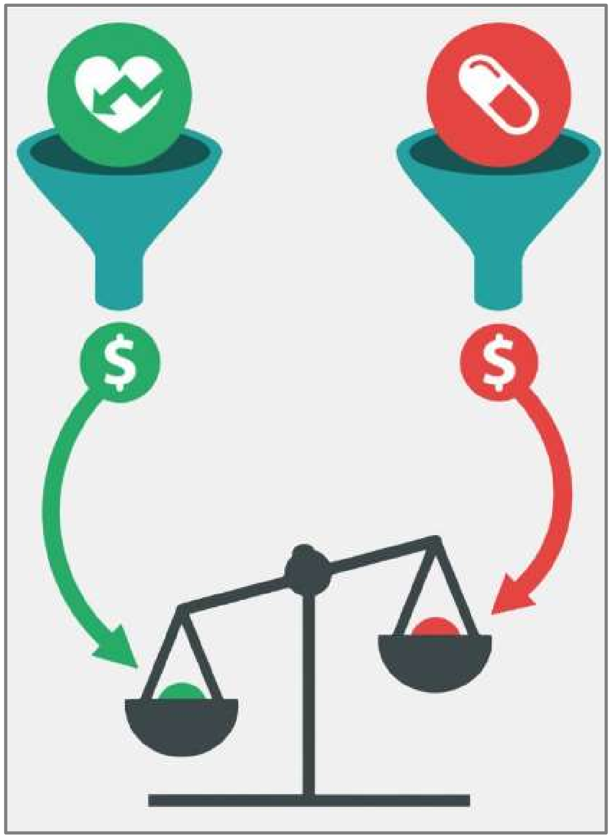


What costs to include?

- Depends on purpose of analysis
- Need to be clear what is/not included
- Include all resources enabling program function
  - Be as thorough as you can
  - Usually focused on service delivery
- Exhaustive costing not possible or worthwhile
  - Cost to develop RUTF
  - UN HQ costs often not included, but contribute to program functioning
- Define your "universe" of costs
  - At what level will you collect cost data? Field only? National?
  - International/HQ support?
  - Cluster coordination?



Pitfalls of under-estimated costs

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Vicious cycle of poor quality cost data

*Minimum standards: **transparent reporting** to understand generalizability of cost estimates*

Analytical perspective: institutional vs societal

Institutional costs (accounting + interviews)

- Staff (time allocation) *****integrated programs***
- Transportation (vehicle logs, logistics)
- Medicines, foods (often donated)
- Support

Societal costs (interviews, surveys, community discussions)

- Shadow wage of volunteers
- Household time & cost

Time allocation

- Always important for economic analysis, especially integrated programs
- Different methods depending on precision needed
- Most basic: conduct time allocation interviews with staff (management, clinical staff, technical support, supervision)
  - Get % time spent on different activities
  - Usually focused on % time for CMAM (or supporting CMAM vs other activities)
  - Involves walking through a usual day/week/month, depending on their work schedule
- Allocate a % of their salary to CMAM
- Use % from interviews to apportion different overhead/support costs

Costing food commodities

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Option 1: Top Down

1. Cost of total shipment from waybills/accounting
2. May be lacking information on additional charges (port of entry, freight, etc.)
3. Estimate transport & storage

Pros: accounts for loss (spoilage, theft)
Cons: less accurate, determine % of total used by your program

Option 2: Bottom Up

1. Calculate total cost per sachet (same as Option 1: product + transport, storage)
2. Quantity of sachets provided per visit per child treated
3. Use monthly caseload data, apply same quantity to all cases

Pros: more accurate, based on program data
Cons: not reality, adj. for loss

Adapted from Sarah King, Heather Stobaugh AAH US

Compiling, organizing cost data

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- Include all costs in one main spreadsheet
  - Can link from other sheets
  - Organize by month
    - Understand resource flow
    - Good level detail (not daily, not annual)
    - Helps spot issues with data gaps, inconsistencies

Input Type	% Allocation	Oct-21	Nov-21	Dec-21	Total 2021
PROGRAM SPECIFIC STAFF					
Program Management					
Field Nutrition Expert	25%	$3,500	$3,500	$3,500	$42,000
Deputy Nutrition PM - Location 1	25%	$3,500	$3,500	$3,500	$42,000
Deputy Nutrition PM - Location 2	25%	$3,500	$3,500	$3,500	$42,000
Nutrition Data & Supply Chain Officer	25%	$3,500	$3,500	$3,500	$42,000
Nutrition Data Clerk - Location 1	25%	$3,500	$3,500	$3,500	$42,000
Nutrition Data Clerk - Location 2	25%	$3,500	$3,500	$3,500	$42,000
Nutrition Officer -Location 1	25%	$3,500	$3,500	$3,500	$42,000
Nutrition Officer - Location 2	25%	$3,500	$3,500	$3,500	$42,000
Community Outreach Officers - Location 1	25%	$3,500	$3,500	$3,500	$42,000
Community Outreach Officers - Location 2	25%	$3,500	$3,500	$3,500	$42,000
OTP/TSFP Staff					
Nutrition Assistants - Location 1	60%	$400	$400	$400	$4,800
Nutrition Assistant - Location 2	60%	$400	$400	$400	$4,800
Community Nutrition Workers - Location 1	60%	$400	$400	$400	$4,800
Community Nutrition Workers - Location 2	60%	$400	$400	$400	$4,800
Community Nutrition Volunteers - Location 1	60%	$400	$400	$400	$4,800
Community Nutrition Volunteers -Location 2	60%	$400	$400	$400	$4,800
Site cleaners - Location 1	10%	$400	$400	$400	$4,800
Site cleaners - Location 2	10%	$400	$400	$400	$4,800
Guards - Location 1	10%	$400	$400	$400	$4,800
Guards - Location 2	10%	$400	$400	$400	$4,800
Stabilization Center Staff					
Roving Medical Doctor	40%	$1,200	$1,200	$1,200	$14,400
SC Medical Doctor	40%	$1,200	$1,200	$1,200	$14,400
SC Nurse	40%	$1,200	$1,200	$1,200	$14,400
SC Cook/Cleaner	40%	$1,200	$1,200	$1,200	$14,400
SC Watchman	40%	$1,200	$1,200	$1,200	$14,400
NATIONAL COORDINATION STAFF					
Country Director	3%	$500	$500	$500	$6,000
Program Director	3%	$500	$500	$500	$6,000
Head of Operations Department	3%	$500	$500	$500	$6,000
Head of Nutrition Department	50%	$500	$500	$500	$6,000
Deputy Head of Nutrition Department	50%	$500	$500	$500	$6,000
Head of Finance Department	10%	$500	$500	$500	$6,000

SPREADSHEET PRESENTATION

Input Type	% Allocation	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Total 2021	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Total 2022	Capital / Recurrent	Personnel / Other	Program / Support	Input Type	Cost Source	Activity (%)	OTP	TSFP	SC	Others	Others		Notes
PROGRAM SPECIFIC STAFF																																		
Program Management																																		
Field Nutrition Expert	25%	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$42,000	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$24,500	Recurrent	Personnel	Program	Staffing									
Deputy Nutrition PM - Location 1	25%	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$42,000	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$24,500	Recurrent	Personnel	Program	Staffing									
Deputy Nutrition PM - Location 2	25%	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$42,000	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$24,500	Recurrent	Personnel	Program	Staffing									
Nutrition Data & Supply Chain Officer	25%	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$42,000	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$24,500	Recurrent	Personnel	Program	Staffing									
Nutrition Data Clerk - Location 1	25%	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$42,000	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$24,500	Recurrent	Personnel	Program	Staffing									
Nutrition Data Clerk - Location 2	25%	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$42,000	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$24,500	Recurrent	Personnel	Program	Staffing									
Nutrition Officer -Location 1	25%	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$42,000	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$24,500	Recurrent	Personnel	Program	Staffing									
Nutrition Officer - Location 2	25%	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$42,000	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$24,500	Recurrent	Personnel	Program	Staffing									
Community Outreach Officers - Location 1	25%	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$42,000	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$24,500	Recurrent	Personnel	Program	Staffing									
Community Outreach Officers - Location 2	25%	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$42,000	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500	$24,500	Recurrent	Personnel	Program	Staffing									
OTP/TSFP Staff																																		
Nutrition Assistants - Location 1	60%	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$4,800	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$28,000	Recurrent	Personnel	Program	Staffing									
Nutrition Assistant - Location 2	60%	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$4,800	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$28,000	Recurrent	Personnel	Program	Staffing									
Community Nutrition Workers - Location 1	60%	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$4,800	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$28,000	Recurrent	Personnel	Program	Staffing									
Community Nutrition Workers - Location 2	60%	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$4,800	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$28,000	Recurrent	Personnel	Program	Staffing									
Community Nutrition Volunteers - Location 1	60%	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$4,800	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$28,000	Recurrent	Personnel	Program	Staffing									
Community Nutrition Volunteers -Location 2	60%	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$4,800	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$28,000	Recurrent	Personnel	Program	Staffing									
Site cleaners - Location 1	10%	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$4,800	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$28,000	Recurrent	Personnel	Program	Staffing									
Site cleaners - Location 2	10%	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$4,800	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$28,000	Recurrent	Personnel	Program	Staffing									
Guards - Location 1	10%	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$4,800	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$28,000	Recurrent	Personnel	Program	Security									
Guards - Location 2	10%	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$4,800	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$28,000	Recurrent	Personnel	Program	Security									
Stabilization Center Staff																																		
Roving Medical Doctor	40%	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$14,400	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$8,400	Recurrent	Personnel	Program	Staffing									
SC Medical Doctor	40%	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$14,400	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$8,400	Recurrent	Personnel	Program	Staffing									
SC Nurse	40%	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$14,400	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$8,400	Recurrent	Personnel	Program	Staffing									
SC Cook/Cleaner	40%	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$14,400	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$8,400	Recurrent	Personnel	Program	Staffing									
SC Watchman	40%	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$14,400	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$8,400	Recurrent	Personnel	Program	Security									
NATIONAL COORDINATION STAFF																																		
Country Director	3%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Personnel	Support	Staffing									
Program Director	3%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Personnel	Support	Staffing									
Head of Operations Department	3%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Personnel	Support	Staffing									
Head of Nutrition Department	50%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Personnel	Program	Staffing									
Deputy Head of Nutrition Department	50%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Personnel	Program	Staffing									
Head of Finance Department	10%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Personnel	Support	Staffing									
Head of HR Department	10%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Personnel	Support	Staffing									
Head Logistics Department	10%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Personnel	Support	Staffing									
SUPPORT STAFF																																		
National Staff																																		
National Support Team Shared Costs	10%	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$36,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$21,000	Recurrent	Personnel	Support	Staffing									
Location 1 & 2 Center Staff																																		
Field Coordinator	30%	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$36,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$21,000	Recurrent	Personnel	Support	Staffing									
Logistics Officer	30%	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$36,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$21,000	Recurrent	Personnel	Support	Staffing									
Logistics Officer	30%	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$36,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$21,000	Recurrent	Personnel	Support	Staffing									
Logistics Assistants	30%	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$36,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$21,000	Recurrent	Personnel	Support	Staffing									
Logistics Assistant	30%	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$36,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$21,000	Recurrent	Personnel	Support	Staffing									
HR Officer	30%	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$36,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$21,000	Recurrent	Personnel	Program	Staffing									
Finance Officer	30%	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$36,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$21,000	Recurrent	Personnel	Program	Staffing									
Finance Admin Assistant	30%	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$36,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$21,000	Recurrent	Personnel	Program	Staffing									
Drivers - Location 1	30%	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$36,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$21,000	Recurrent	Personnel	Program	Staffing									
Drivers - Location 2	30%	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$36,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$21,000	Recurrent	Personnel	Program	Staffing									
PROGRAM COSTS																																		
OTP/TSFP																																		
RUTF	100%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Other	Program	Inputs									
OTP/TSFP Running Costs	100%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Other	Program	Inputs									
OTP/TSFP Supplies	100%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Other	Program	Inputs									
Nutrition Site Contruction/Rehabilitation	100%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Capital	Other	Program	Capital									
Nutrition Team Meetings	100%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Other	Program	Inputs									
Amoxicillin	100%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Other	Program	Inputs									
Stabilization Center																																		
SC Running Cost	20%	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$12,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$7,000	Recurrent	Other	Program	Inputs									
SC Supplies	20%	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$12,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$7,000	Recurrent	Other	Program	Inputs									
SC Commodities	20%	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$12,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$7,000	Recurrent	Other	Program	Inputs									
SC Drug Supply	20%	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$12,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$7,000	Recurrent	Other	Program	Inputs									
OFFICE RUNNING COSTS																																		
Field Offices																																		
Office Rent & Running Costs	15%	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$4,800	$400	$400	$400	$400	$400	$400	$400	$2,800	Recurrent	Other	Support	Overheads									
Office Furniture & Equipment	15%	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$4,800	$400	$400	$400	$400	$400	$400	$400	$2,800	Recurrent	Other	Support	Overheads									
Office Supplies & Stationary	15%	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$4,800	$400	$400	$400	$400	$400	$400	$400	$2,800	Recurrent	Other	Support	Overheads									
Office Generator Maintenance	15%	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$4,800	$400	$400	$400	$400	$400	$400	$400	$2,800	Recurrent	Other	Support	Overheads									
Communication Charges	15%	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$4,800	$400	$400	$400	$400	$400	$400	$400	$2,800	Recurrent	Other	Support	Overheads									
Office Security	15%	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$4,800	$400	$400	$400	$400	$400	$400	$400	$2,800	Recurrent	Other	Support	Security									
National Office																																		
National Office Rent & Running Costs	5%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Other	Support	Overheads									
National Office Security	5%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Other	Support	Overheads									
National Office Supplies & Stationary	5%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Other	Support	Overheads									
National Office Generator Maintenance	5%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Other	Support	Overheads									
National Financial Fees	5%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Other	Support	Overheads									
Office Communication Charges	5%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Other	Support	Overheads									
Office Security	5%	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$6,000	$500	$500	$500	$500	$500	$500	$500	$3,500	Recurrent	Other	Support	Security									
TRANSPORTATION																																		
Vehicle																																		
Support Vehicle Running Costs	15%	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$1,200	$100	$100	$100	$100	$100	$100	$100	$700	Recurrent	Other	Support	Transport									
Support Vehicle Running Costs	15%	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$1,200	$100	$100	$100	$100	$100	$100	$100	$700	Recurrent	Other	Support	Transport									
Nut Program Vehicle Running Costs	80%	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$1,200	$100	$100	$100	$100	$100	$100	$100	$700	Recurrent	Other	Program	Transport									
Freight																																		
Freight of Supplies & Equipment	50%	$200	$200	$200	$200	$200	$200	$200	$200	$200	$200	$200	$200	$2,400	$200	$200	$200	$200	$200	$200	$200	$1,400	Recurrent	Other	Support	Transport									
OTHER DIRECT COSTS																																		
Laptops & Printers	50%	$50	$50	$50	$50	$50	$50	$50	$50	$50	$50	$50	$50	$600	$50	$50	$50	$50	$50	$50	$50	$350	Capital	Other	Support	Capital									
Thurayas	50%	$50	$50	$50	$50	$50	$50	$50	$50	$50	$50	$50	$50	$600	$50	$50	$50	$50	$50	$50	$50	$350	Capital	Other	Support	Capital									
Smart Phones	50%	$50	$50	$50	$50	$50	$50	$50	$50	$50	$50	$50	$50	$600	$50	$50	$50	$50	$50	$50	$50	$350	Capital	Other	Support	Capital									
Satphones	50%	$50	$50	$50	$50	$50	$50	$50	$50	$50	$50	$50	$50	$600	$50	$50	$50	$50	$50	$50	$50	$350	Capital	Other	Support	Capital									

Uncertainty

- In a sense, costs are deterministic in a certain context
- One cost for monthly facility rental, vehicles, etc.
- It can be helpful to think of uncertainty in costs
  - Extrapolating across contexts
  - Sensitivity analyses: changes in key input prices (RUTF, fuel, etc.)
- Mark will discuss uncertainty in his presentation, these concepts can apply to costs as well

DALYs

The basic ideas

Cost effectiveness

Cost effectiveness (CE) is based on a very simple idea:

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

here ***cost*** is the amount of money spent on a program over a defined period of time and ***outcome*** is the number of ***desired positive outcomes*** delivered by the program over the same period of time.

If, for example, a program cost US$119,697 and cured 653 case of severe acute malnutrition (SAM) then the cost per case recovered is calculated as:

$$\frac{US\,\$\,119{,}697}{653} = US\,\$\,183.30\ per\ case\ recovered$$

Here we are treating ***curing SAM*** as the ***desired positive outcome***.

Desired positive Outcomes

Examples of d***esired positive outcomes*** include:

Cases treated : This is the number of cases treated by a program ***regardless of outcome***. The effectiveness (e.g., the cure rate) of the treatment is **<u>not</u>** taken into account. Analyses using this outcome are ***cost-efficiency*** rather than as cost-effectiveness analyses. This type of analysis is usually only useful for well-proven and highly effective treatment or for primary prevention (e.g. vaccine) programs. You may see comparative analysis of this type for CMAM programming.

Cases recovered (case cured) : This is the number of cases treated by a program that ***were cured***. Analyses using this positive outcome are ***cost-effectiveness*** analyses

Lives saved (deaths averted): This is the number of lives saved, which is the same as the number of deaths averted, by a program. This is an important measure of ***cost-effectiveness*** for programs treating conditions associated with high mortality in young children such as severe acute malnutrition (SAM). The calculation of the number of lives saved requires the use of a ***counterfactual*** (i.e. an informed guess about what would likely have happened ***in the absence of the program***) derived from cases recovered and the expected mortality in untreated cases.

Disability adjusted life-years averted ($\mathbf{DALY_{AVERTED}}$) : Based on the DALY - a standardised quantitative measure of the burden of disease that combines mortality and morbidity:

$$DALYs = Mortality + Morbity$$

DALYs have some advantages over alternatives. DALYs provide a single metric combining negative effects of early death and morbidity on wellbeing for specific diseases and treatments.

Mortality + Morbity

Mortality is **not** difficult to quantify …

$$Mortality \;=\; Life\text{-}expectancy \;-\; age\,at\,death\;for\,a\,case\,of\;the\,disease$$

This is the years of life lost (***YLL***) due to the disease.

Morbidity is not so easy to quantify …

Each illness effect is given a severity rating called a ***disability weight*** determined using expert medical opinion and (sometimes) surveys and studies). Disability weights range between 0 (fully healthy) to 1 (fully disabled or dead). A value around 0.3 is typically for long tern chronic illnesses. Tables of agreed disability weights are published periodically (every few years) for use in global burden of disease (GBD) studies.

Sequela	Average disability weight (a)	Range (b)
Tuberculosis - Cases	0.271	0.264 - 0.294
Syphilis		
Congenital syphilis	0.315	
Primary	0.015	0.014 - 0.015
Secondary	0.048	0.044 - 0.048
Tertiary – Neurologic	0.283	
Chlamydia		
Cervicitis	0.049	
Neonatal pneumonia	0.280	
Ophthalmia neonatorum	0.180	
Pelvic inflammatory disease	0.329	0.194 - 0.382
Ectopic pregnancy	0.549	
Tubo-ovarian abscess	0.548	
Chronic pelvic pain	0.122	
Infertility	0.180	
Symptomatic urethritis	0.067	
Epididymitis	0.167	

WHO (2004), *The global burden of disease 2004 update: Disability weights for diseases and conditions*, Geneva: World Health Organisation.

Disability weights

Note that some GBD disability weights may have questionable face-validity in the sense that they do not appear to accurately reflect the concept that they purport to represent. For example:

> Urinary incontinence ($d = 0.142$) is weighted as being a more severe condition than "treated" paraplegia ($d = 0.047$), which commonly involves urinary incontinence ("neurogenic bladder") as well as other disabilities.
>
> Dental caries is weighted $d = 0.081$ but wasting is weighted $d = 0.053$. Is it sensible to treat tooth decay as worse (i.e. a more severe disabling condition) than emaciation?

Such inconsistencies are gradually being resolved. For example dental caries (GBD 2004) weighted d = 0.142 and dental caries (GBD 2019) weighted d = 0.01. Also … we might combine disabilities associated with paraplegia.

Morbidity

Effects of disease can be short or long term so we factor in the duration of disability:

$$Morbidity \;=\; Disability\,weight \;\times\; Duration\,of\;disability$$

If we measure time in years we get the number of years living with disability (**YLD**) for a specific disease and:

$$DALYs \;=\; YLL \;+\; YLD$$

It is important to keep track of the units of time used in each YLL / YLD calculation sticking with expressing times in years.

DALYs Example for adult onset diabetes in plain language / numbers

If an individual with adult onset diabetes dies at age 60 instead of at the life expectancy ***without diabetes*** of 75 years then:

$$YLL = 75 - 60 = 15$$

If morbidity due to (e.g.) foot or kidney, eye, or neurological complications is 0.5 (50% disability) for the final ten years of life then:

$$YLD = 0.5 \ \ timez \ \ 10 = 5$$

In this example the overall disease burden for an individual is:

$$DALYs = YLL + YLD = 15 + 5 = 20\, DALYs$$

This is the mortality and morbidity we see in the ***absence of intervention***. We call this the ***counterfactual***.

If an intervention extends life by ten years:

$$YLL = 75 - 65 = 10$$

and reduces the duration of disability from 10 years to 4 years:

$$YLD = 4 \times 0.5 = 2$$

DALYs Example for adult onset diabetes (continued) ...

The mortality and mortality we see in the ***presence of intervention*** is:

$$DALYs = YLL + YLD = 10 + 2 = 12$$

We can say that the intervention averted:

$$DALYs_{Averted} = counterfactual - factual = 20 - 12 = 8\,DALYs$$

$DALYs_{Averted}$ is the ***health benefit*** of an intervention (i.e. the reduction in morality and morbidity compared to doing nothing (the ***counterfactual***). Health intervention aim to avert DALYs.

The three-stage approach:

(1) Assess the mortality and morbidity associated with the condition on interest in the absence of intervention (the ***counterfactual***)

(2) Assess the mortality and morbidity associated with the condition of interest in the presence of the intervention of interest. (the ***factual***)

(3) Compare (1) and (2) to find the reduction in morality and morbidity averted by the intervention.

Provides a useful framework for cost-effectiveness analysis using DALYs.

Summary

DALYs is the burden of disease.

The DALY is a common metric that allows ...

(1) Direct comparison of burden across diseases

(2) Comparison of treatment and untreated diseases

(3) Summing of burdens across diseases

(4) Comparison of the effects of different interventions.

Cost-effectiveness studies using DALYs can be complicated to do (some examples later) but are ***usually conceptually simple.***

DALYs

for SAM (CMAM) treatment

Background

Here we work with data from a CMAM program from Bangladesh:

Number admitted	711
Number cured (discharged alive)	653
Average length of a cured episode	37.4 days
Average length of an untreated episode	182.5 days (6 months)
Average MUAC at admission	106.7 mm

We will stick with the three-stage approach:

(1) Assess the mortality and morbidity associated with the condition on interest in the ***absence of intervention*** (the ***counterfactual***)

(2) Assess the mortality and morbidity associated with the condition of interest in the ***presence of the intervention on interest*** (the ***factual***).

(3) Compare (1) and (2) to find the reduction in morality and morbidity averted by the intervention.

The counterfactual for mortality

DALYs measure mortality in terms of years of life lost (YLL). We estimate YLL by first estimating mortality in an imagined cohort of untreated cases with a similar severity of disease as the cases successfully treated by the program and correcting this for background mortality:

$$\textit{Expected mortality}_{\textit{Counterfactual}} = \textit{Case fatality rate}_{\textit{Untreated SAM}} - \textit{Background mortality}$$

We can find the expected case fatality rate in untreated SAM cases using historical cohort data.

Figure 1 shows the case fatality rates (in deaths / 1,000 cases / year) at different levels of MUAC reported by four historical cohort studies. There is little between-study variation in the observed relationships between MUAC and mortality despite the fact that these studies were undertaken by different teams in different locations at different times with varying lengths of follow-up and inconsistent censoring of accidental and violent deaths. This suggests that each study is estimating the same underlying rates and the observed differences were due to varying lengths of follow-up, inconsistent censoring of accidental and violent deaths, measurement error, and sampling variation. Table 1 shows the same data as Figure 1 for different levels of MUAC less than or equal to 125 mm.

Figure 1 : Case fatality rates at different levels of MUAC reported by four historical cohort studies in deaths / 1,000 cases / year

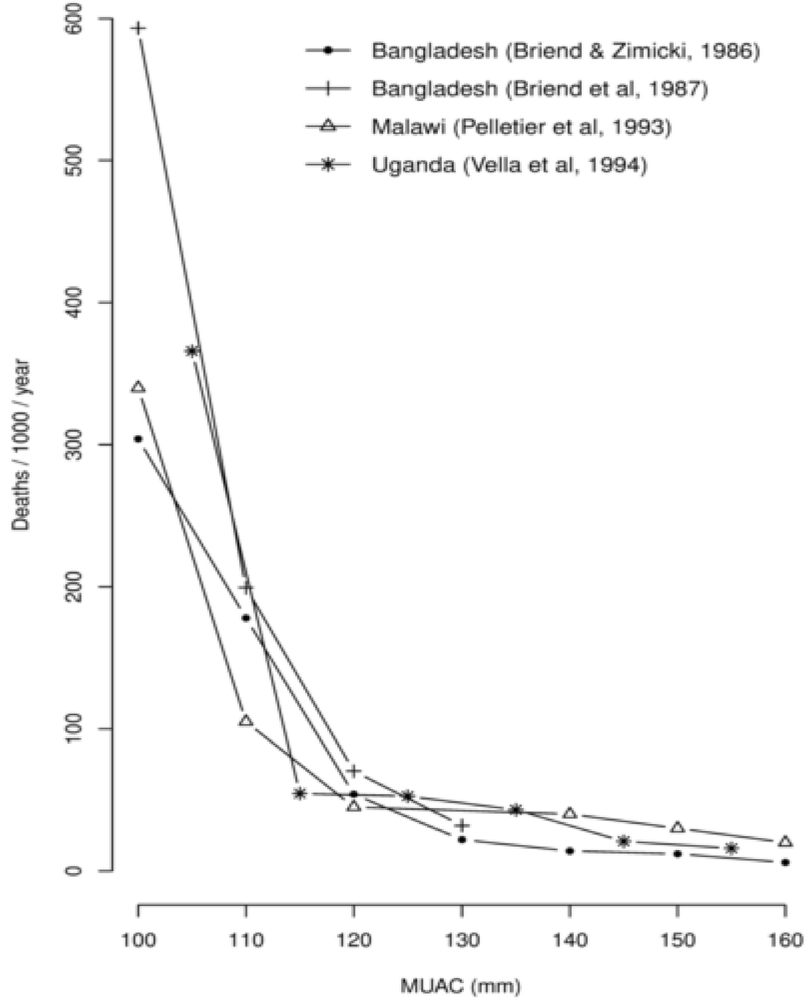
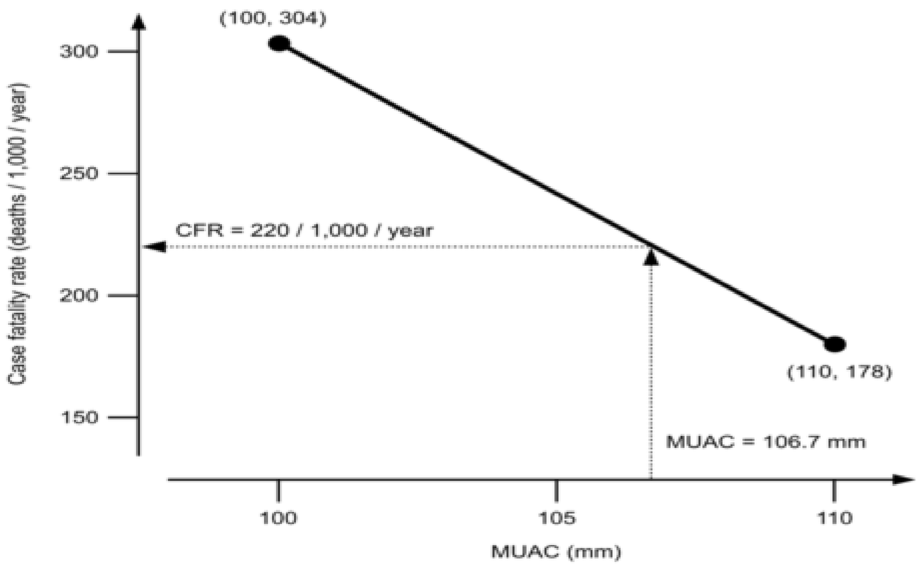


Table 1 : Case fatality rates for different levels of MUAC reported by four historical cohort studies in deaths / 1,000 cases / year for different levels of MUAC

		MUAC (mm)					
Country	**Study**	**100**	**105**	**110**	**115**	**120**	**125**
Bangladesh	Briend & Zimicki (1986)	304		178		54	
	Briend, el al (1987)	593		199		70	
Malawi	Pelletier et al (1993)	340		105		45	
Uganda	Vella et al (1994)		366		55		53

The average MUAC at admission in the cured cases in the example program from Bangladesh was 106.7 mm. There is no column in Table 2 that exactly matches 106.7 mm. We can, however, use a linear interpolation procedure to estimate mortality in children with MUAC = 106.7 mm.

Figure 2 :Linear interpolation using the Briend & Zimicki (1986) results to estimate the case fatality rate for children with MUAC = 106.7 mm



Using the Briend & Zimicki (1986) results to estimate the case fatality rate for children with MUAC = 106.7 mm arithmetically, we have (x1, y1) = (100, 304) and (x2, y2) = (110, 178). The case fatality rate associated with MUAC = 106.7 mm can be estimated:

$$
\begin{aligned}
CFR &= y_1 - \frac{y_2 - y_2}{x_2 - x_1} \times (z_1 - MUAC) \\
&= 304 - \frac{178 - 304}{110 - 100} \times (100 - 106.7) \\
&= 219.58 \ \ deaths / 1{,}000 / \ year
\end{aligned}
$$

Figure 2 (previously) shows this procedure done graphically.

We should repeat this calculation for the reported case fatality rates from each of the four historical cohort studies. The data, calculations, and results for MUAC = 106.7 mm are shown in Table 2.

Table 2 : Case fatality rates for MUAC = 106.7 mm from four cohort studies

$\mathbf{x_1}$	$\mathbf{y_1}$	$\mathbf{x_2}$	$\mathbf{y_2}$	**Case fatality rate** (deaths / ,1000 / year)
100	304	110	178	304 – (178 – 304) / (110 - 100) × (100 - 106.7) = 219.58
100	593	110	199	593 – (199 – 593) / (110 - 100) × (100 - 106.7) = 329.02
100	340	110	105	340 – (105 – 340) / (110 - 100) × (100 - 106.7) = 182.55
105	366	115	55	366 – (55 – 366) / (115 - 105) × (105 - 106.7) = 313.13

It seems reasonable (i.e. from an inspection of Figure 1) to assume that each study is estimating the same underlying rates and the observed differences were due to varying lengths of follow-up, inconsistent censoring of accidental and violent deaths, measurement error, and sampling variation. This means that an average of the four case fatality rates is likely to provide a better estimate than is available from a single study.

A useful average to use when working with rates is the harmonic mean:

$$Harmonic\,mean = \frac{n}{\frac{1}{y_1} + \frac{1}{y_2} + \ldots + \frac{1}{y_n}}$$

With the case fatality rates calculated in Table 2 the harmonic mean is:

$$\overline{CFR} = \frac{4}{\frac{1}{219.58} + \frac{1}{392.02} + \frac{1}{182.55} + \frac{1}{313.123}} = 245.93 \;\; deaths \,/\, 1{,}000 \,/\, year$$

This estimate of expected mortality will include baseline or background mortality and may cause us to overestimate YLL, the number of lives saved by the intervention, and the YLL_{Averted} component of $DALYs_{\text{Averted}}$ estimates. Some adjustment to account for baseline mortality is required.

The average under five-years mortality rate (U5MR) for the locations (i.e. countries) and times of the four cohort studies was about 1 death per 10,000 children per day. This is same as 36.5 deaths per 1,000 children per year. Applying this adjustment yields:

$$\overline{CFR} = 245.93 - 36.5 = 209.43 \;\; deaths \,/\, 1{,}000 \,/\, year$$

It is often useful to present this as a proportion:

$$Expected\ Mortality_{Proportion} = \frac{209.43}{1000} = 0.20943 = 20.943\%$$

The number of lives saved (or deaths averted) can then be estimated:

$$Lives\,Saved \;=\; Deaths\;Averted \;=\; Expected\;Mortality_{Proportion} \times Number_{Cured} \;=\; 0.20943 \;\times\; 653 = 136.7578$$

We can convert this to $\mathrm{YLL}_{\mathrm{Averted}}$ by multiplying this by the life expectancy at the time of death. A ***standard life expectancy*** known as the 'standard expected years of life lost' (SEYLL) may be used:

Table 4 : Standard Expected Years of Life Lost (SEYLL)

Age at death (years)	**Standard expected years of life lost (SEYLL)***
0	91.94
1	91.00
2	90.01
3	89.01
4	88.02
5	87.02

The average age at admission to the example program was 19 months. We need this expressed in years:

$$Age\,at\;admission \;=\; \frac{19}{12} \;=\; 1.5833$$

Time to death can only be guessed at. A sensible guess is that some deaths occur quite quickly (i.e. about half of all deaths occur after only two months) and all deaths that are reasonably attributable to SAM occur before about 7.5 months. Two months Expressed as years is:

$$2\,months \;=\; \frac{2}{12} \;=\; 0.1667\,years$$

this gives:

$$Age\ at\ death \ = \ Age\ at\ admission \ + \ time\ to\ death \ = \ \frac{19 \ + \ 2}{12} \ = \ 1.75\ years$$

and:

$$YLL_{Averted} \ = \ 136.7578 \ \times \ (91.94 \ - \ 1.75) \ = \ 12334.1860$$

This SEYLL approach is currently recommended by the WHO for estimating burden.

Prior to 2010, it was common practice to use ***local life expectancies***. Moving from using local life expectancy to SEYLL will usually increase estimates of $\mathrm{YLL}_{\mathrm{Averted}}$ because the SEYLL is based on projections to the year 2050 using data from developed countries with long life expectancies. This SEYLL may **not** be appropriate for estimating $\mathrm{YLL}_{\mathrm{Averted}}$ for CMAM programs which are often run in low- and middle-income countries (LMIC) which have considerably shorter life-expectancies than SEYLL. It may be more realistic to use ***local life-expectancies***.

The WHO Global Health Observatory figure for life expectancy at birth for Bangladesh for males and females combined is 66.6 years for the time the program was running. This means that a shift from using local life expectancy to SEYLL will increase the estimate of $\mathrm{YLL}_{\mathrm{Averted}}$ by a factor of about:

$$\frac{91.94}{66.6} \ \approx \ 1.38$$

Just checking:

$$YLL_{Averted} = 136.7578 \times (66.6 - 1.75) = 8868.7430$$

The inflation due to using SEYLL rtaher than local life expectancies is:

$${}_{1}\ \frac{12334.1860}{8868.7430} = 1.39$$

If you need to compare $DALY_{Averted}$ between your program and programs that reported DALYs calculated using local life-expectancies, then you will need to use an estimate of local life expectancy to calculate $YLL_{Averted.}$ In this case $YLL_{Averted}$ is calculated as:

$$YLL_{Averted} = Lives\ saved \times (\boldsymbol{Local}\ life\ expectancy\ at\ birth - Average\ age\ at\ death)$$

Prior to 2010, it was common practice to use ***local life expectancies***. Moving from using local life expectancy to SEYLL will usually increase estimates of $YLL_{Averted}$ because the SEYLL is based on projections to the year 2050 using data from developed countries with long life expectancies. This SEYLL *may* **not** be appropriate for estimating $YLL_{Averted}$ for CMAM programs which are often run in low- and middle-income countries (LMIC) which have considerably shorter life-expectancies than SEYLL. It is likely more realistic to use local life-expectancies.

A counterfactual for Morbidity (YLD)

Estimating the number of years living with disability (YLD) averted ($YLD_{Averted}$) by an intervention requires the construction of a counterfactual.

The counterfactual is an informed guess at what would have happened in the absence of the intervention.

To use the basic YLD formula:

$$YLD = Duration\ of\ disease\ episode \times Disability\ Weight$$

we need to calculate the difference between the durations of disease (t) for untreated and treated SAM episodes:

$$\Delta_t = t_{Untreaded\ SAM} - t_{Treated\ SAM}$$

This is the duration of the SAM episode that is averted by treatment.

It is common to use the duration of SAM episodes from treatment to discharge as cured in the program under study for treated SAM. This is calculated for recovered cases only. Treatment episodes resulting in death, transfer, or default are not usually considered.

We usually know the length of a successfully treated episode of SAM. This is the length of stay in the program for SAM cases that were discharged as cured.

We do not usually know the duration of an untreated episode of SAM. It is common practice to use six months. This figure is derived from historical (i.e., from the late twentieth century) cohort studies

A counterfactual for Morbidity (YLD)

If the length of a successfully treated episode of SAM is (e.g.) two months and the length of an untreated episode of SAM is six months, then:

$$\Delta_t = t_{Untreaded\ SAM} - t_{Treated\ SAM} = 6 - 2 = 4\,months$$

The effect of treatment is to shorten the duration of the disease episode by four months.

The disability weight for SAM is $d = 0.127$. For episodes of severe wasting the program averted:

$$YLD_{Averted} = 4/12 \times 0.127 = 0.0423$$

We could calculate $\mathrm{YLD}_{\mathrm{Averted}}$ for every SAM case that was discharged as cured by a program. The sum of these individual $\mathrm{YLD}_{\mathrm{Averted}}$ figures would be the estimate of the $\mathrm{YLD}_{\mathrm{Averted}}$ by the program.

<u>BUT …</u> Working with individual data can be expensive and time-consuming. It also raises issues of confidentiality and data protection and may be illegal in some settings unless all identifying data is removed.

We usually work, therefore, with summary measures (e.g., counts of cases and average lengths of treatment episodes) taken from routine program monitoring statistics.

A counterfactual for Morbidity (YLD)

Here are the relevant program monitoring statistics for the example CMAM program:

Number admitted*	711
Number cured**	653
Average length of a cured episode	37.4 days
Average length of an untreated episode	182.5 days (6 months)

If we assume that all SAM cases were admitted with severe wasting only then the average YLDAverted for each case is:

$$YLD_{Averted} = \frac{(182.5 - 37.4)}{365} \times 0.127 = 0.0505$$

The $\text{YLD}_{\text{Averted}}$ by the program was:

$$YLD_{Averted} = 0.0505 \times 653 = 32.9765$$

A counterfactual for Morbidity (YLD)

This analysis assumes that all SAM cases were admitted with severe wasting only. It is usually safe to do this because kwashiorkor is a rare condition and tends to account for only a small proportion of program caseload. In the example CMAM program in Bangladesh there were just six (0.84% of all admissions) cases of kwashiorkor and seven (0.98% of all admissions) cases of concurrent severe wasting with kwashiorkor. Also, the contribution of the $YLD_{Averted}$ component of the $DALY_{Averted}$ calculation:

$$DALY_{Averted} = YLD_{Averted} + YLL_{Averted}$$

will be small compared to the $YLL_{Averted}$ component (i.e., the mortality averted) for an acute condition which is associated with high mortality such as SAM.

If a large proportion of SAM cases are admitted with kwashiorkor, then you may want to calculate $YLD_{Averted}$ for each type of SAM separately and add them together.

The full counterfactual for DALYS$_{\text{Averted}}$

Recall:

$$DALY_{Averted} = YLL_{Averted} + YLD_{Averted}$$

We get:

$$DALYs_{Averted} = YLL_{Averted} + YLDAverted = 12334.1860 + 32.9765 = 12367.1625$$

DALYs

Uncertainty

Uncertainty

This analysis presented thus far provides only point estimate of $YLL_{Averted}$, $YLD_{Averted}$ and, hence. $DALYs_{Averted}$. A method that yields a range of values for DALY components and DALYS that accounts for the uncertainty and variability in mortality risks, durations, disability, and the proportion cured would be both more useful and more credible.

Accounting for uncertainty

Uncertainty can be incorporated into estimates using ***triangular fuzzy numbers***. Using triangular fuzzy numbers to account for uncertainty is similar to using a sampling-based approach to uncertainty.

A triangular fuzzy number is a generalisation of a "regular" real number in the sense that it does not refer to a single value but rather to a connected set of possible / probable values. Each possible / probable value has its own weight or membership function (μ) which is a measure of the degree of membership in the set of all possible values. The membership function (μ) ranges between zero and one. Impossible values have a weight of zero, the most likely value has a weight of one, and all other possible / probable values have a weight above zero but below one.

We do not need to worry about specifying explicit mathematical or probabilistic membership functions when using triangular fuzzy numbers. We need only specify the ***minimum***, ***most likely***, and the ***maximum*** values for each quantity . This is useful because in many situations we can usually estimate the minimum, maximum, and the most likely values even if we do not know the exact shape of the sampling distribution.

Representing fuzzy triangular numbers

Triangular fuzzy numbers can be represented using just three points.

We can specify triangular fuzzy numbers using the ***minimum***, ***most likely***, and ***maximum*** values for a quantity. This is useful because in many situations we can usually estimate the minimum, maximum, and the most likely values even if we do not know the exact shape of the sampling distribution.

When deciding on the minimum, maximum, and the most likely values to use, it is important give a "typical" value for the most likely value. This is usually a measure of central tendency. The median (i.e., the middle value) is a good measure of central tendency to use as it is not overly influenced by extreme values. The mode (i.e., the most common value) and the mean are also useful measures of central tendency to use.

The minimum and maximum values need only cover the most likely range of values. This is the case when we use the 95% uncertainly limits for disability weights and approximate 95% confidence limits for proportions. It is usually a good idea to ignore extreme or "outlying", possibly erroneous, observations when specifying minimum and maximum values. Including outliers may seriously (and spuriously) degrade the precision of final results in DALY calculations).

Triangular fuzzy numbers are usually presented as lists of lowest, central and highest values such as:

$$A = (a_{1,} \;\; a_{2,} \;\; a_3)$$

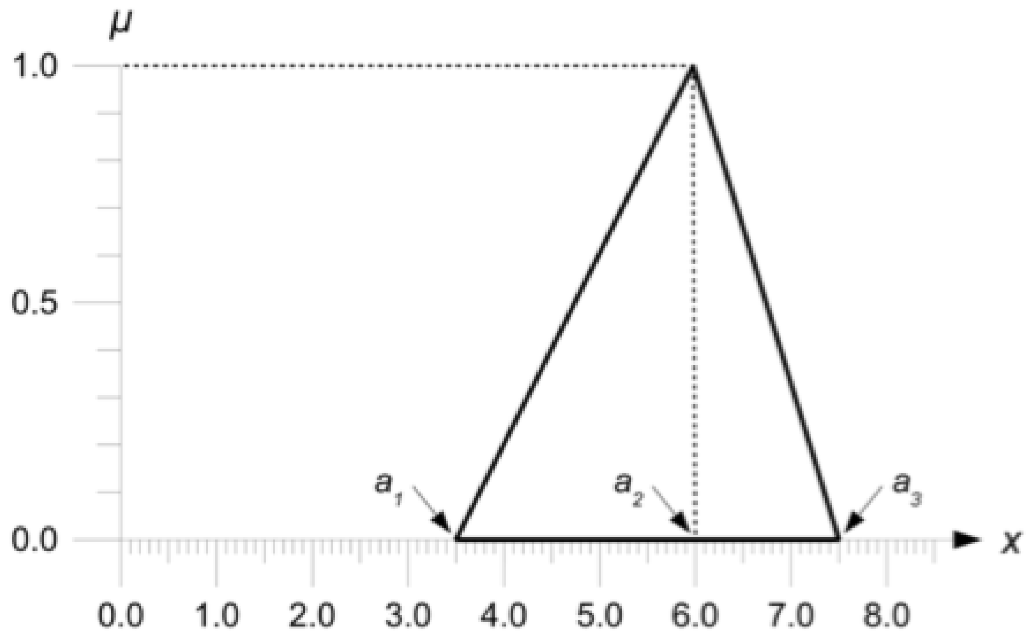
Representing fuzzy triangular numbers

The duration of an untreated episode of SAM might range between 3.5 months (a_1) and 7.5 months (a_3) with a central (most likely) value of 6.0 months (a_2):

$$A = (3.5, \; 6.0, \; 7.5)$$

Fuzzy triangular numbers can also be represented graphically:

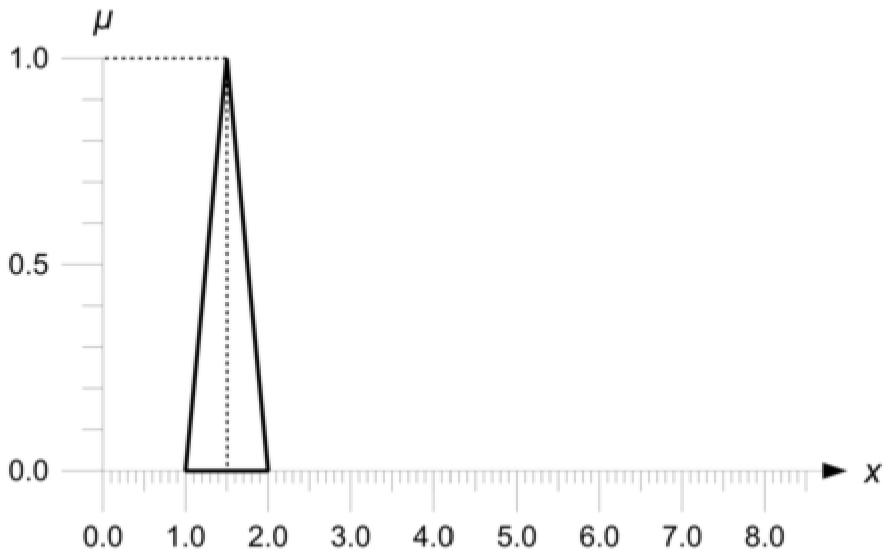
Duration of an untreated episode of SAM expressed
as a triangular fuzzy number



The duration of a treated episode of SAM shown here ranges between 1.0 months (b1) and 2.0 months (b3) with a central (most likely) value at 1.5 months (b2):

$$B = (1.0,\ 1.5,\ 2.0)$$

Duration of a treated episode of SAM expressed as a triangular fuzzy number



These values approximate program data. The minimum length of stay in the example program (b1) was 28 days (i.e. four weeks). This was a program rule. All exits before four weeks were transfers to hospital, defaulters, or deaths. Four weeks is approximated as one month. The average length of stay in the example program was 37.4 days. This is approximated as 1.5 months. The maximum length of stay in the example program was 56 days (i.e. eight weeks). This was also a program rule. Beneficiaries that failed to meet discharge criteria for cure after eight weeks were referred to hospital. Eight weeks is approximated as 2.0 months.

Working with fuzzy triangular numbers

Using the basic YLD formula:

$$YLD = Duration\ of\ disease\ episode \times Disability\ Weight$$

we need to work out the difference between the durations of untreated and treated SAM episodes. These are the triangular fuzzy numbers expressed previously:

$$A = (3.5,\ 6.0,\ 7.5)$$
$$B = (1.0,\ 1.5,\ 2.0)$$

We want to find:

$$C = A - B$$

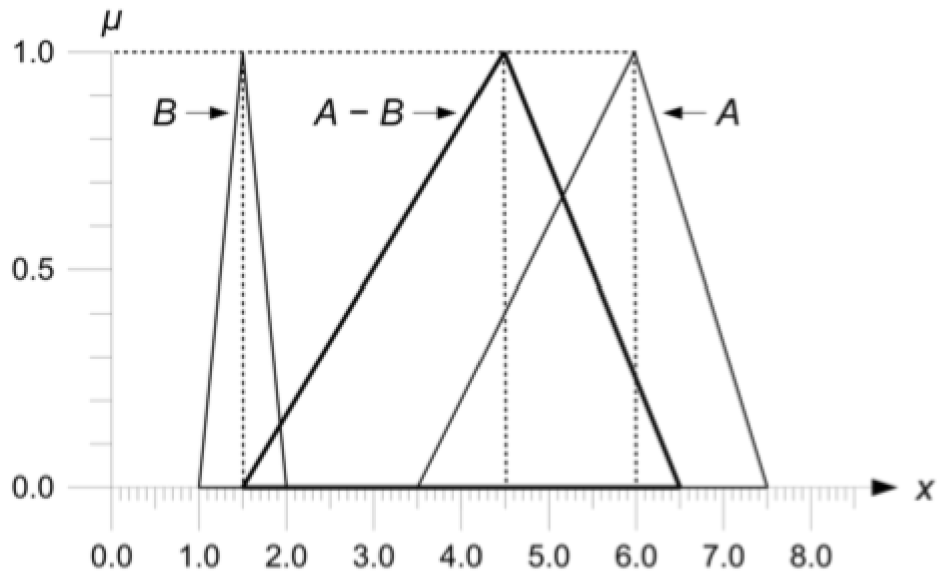
with the result expressed as a triangular fuzzy number.

Operations will be covered soon. We are dealing with positive numbers only so we may use the simpler procedure:

$$A - B = (a_1 - b_{3,}\ a_2 - b_{2,}\ a_3 - b_1)$$
$$A - B = (3.5 - 2.0,\ 6 - 1.5,\ 7.5 - 1.0)$$
$$A - B = (1.5,\ 4.5,\ 6.5)$$

Working with fuzzy triangular numbers

The fuzzy operation C = A – B where A = (3.5, 6.0, 7.5)
and B = (1.0, 1.5. 2.0)



$$A - B = (a_1 - b_{3,}\ a_2 - b_{2,}\ a_3 - b_1)$$

Arithmetic operations with fuzzy numbers

The basic arithmetic operations for fuzzy numbers are:

Given:

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

then:

$$A + B = (a_1 + b_{1,}\ a_2 + b_{2,}\ a_3 + b_3)$$
$$A + B = (3 + 1,\ 6 + 2,\ 8 + 3)$$
$$A + B = (4,\ 8,\ 11)$$

$$A - B = (a_1 - b_{3,}\ a_2 - b_{2,}\ a_3 - b_1)$$
$$A - B = (3 - 3,\ 6 - 2,\ 8 - 1)$$
$$A - B = (0,\ 4,\ 7)$$

$$A \times B = (a_1 \times b_{1,}\ a_2 \times b_{2,} a_3 \times b3)$$
$$A \times b = (3 \times 1,\ 6 \times 2,\ 8 \times 3)$$
$$A \times B = (3,\ 12,\ 24)$$

$$A \div B = (a_1 \div b_{3,}\ a_2 \div b_{2,}\ a_3 \div b_1)$$
$$A \div B = (3 \div 3,\ 6 \div 2,\ 8 \div 1)$$
$$A \div B = (1,\ 3,\ 8)$$

These are the equivalent of ordinary arithmetic operations (i.e. add., subtract, multiply, and divide).

Special cases

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

$$A \div 12 = (a_1 \div 12,\ a_2 \div 12,\ a_3 \div 12)$$
$$A \div 12 = (3 \div 12,\ 6 \div 12,\ 8 \div 12)$$
$$A \div 12 = (0.2500,\ 0.5000,\ 0.6667)$$

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

$$A \odot B = (min\,(a_1 \odot b_1, a_1 \odot b_3,\ a_3 \odot b_1,\ a_3 \odot b_3),\ a_2 \odot b_2,\ max\,(a_1 \odot b_1, a_1 \odot b_3,\ a_3 \odot b_1,\ a_3 \odot b_3))$$

where $\odot$ is the operation (i.e., addition, subtraction, multiplication, or division) required, ***min*** represents the minimum (i.e., smallest value) of a set of numbers, and ***max*** represents the maximum (i.e., largest value) of a set of numbers.

Care needs to be taken to avoid divisions by zero.

It is unlikely that the more complicated 'minimum / maximum rule' method will be needed in DALY calculations.

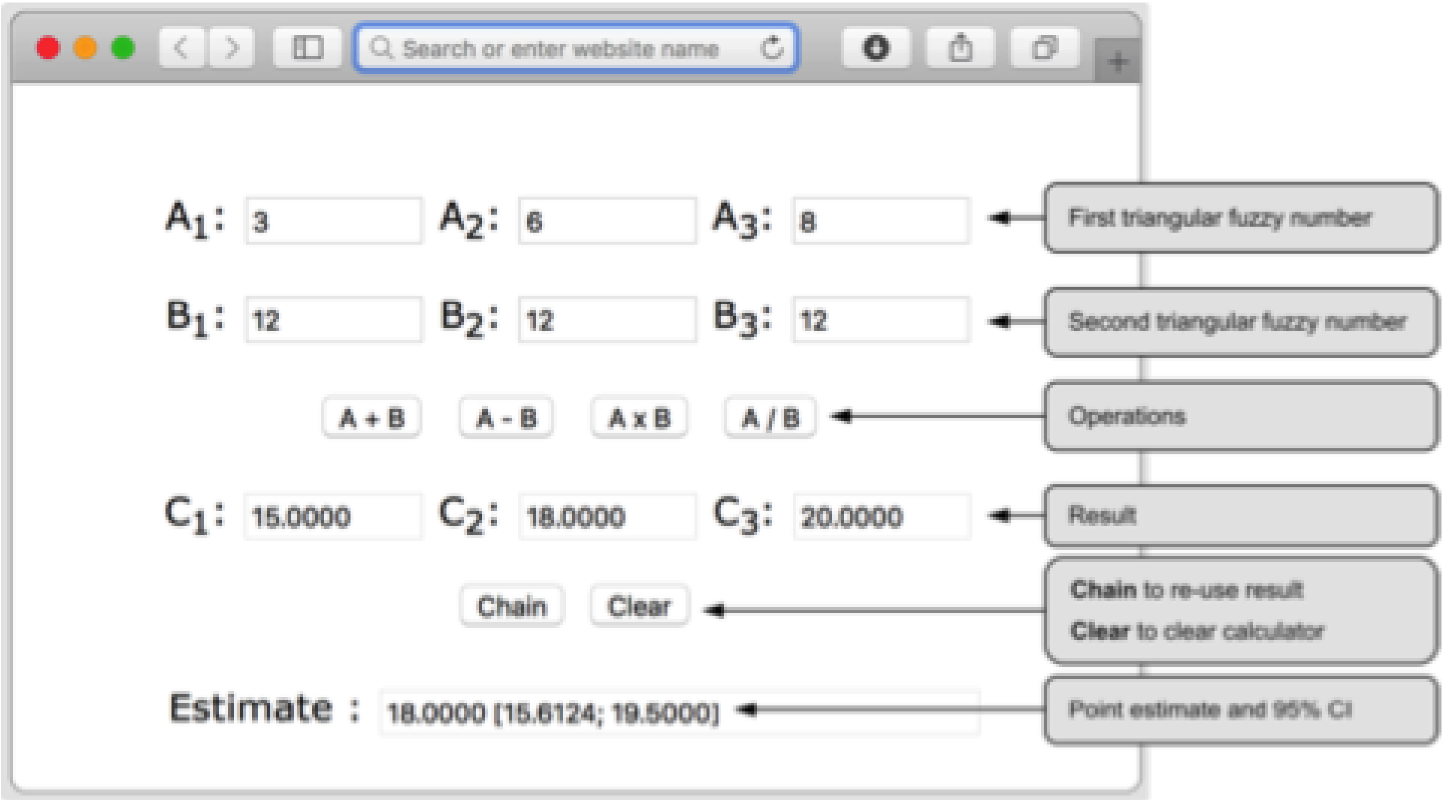
The rules of arithmetic with triangular fuzzy numbers are simple but ***tedious to perform***. The large number of operations required for even simple calculations can make mistakes quite common. It is usually best to use a fuzzy arithmetic calculator.

A fuzzy arithmetic calculator

A fuzzy arithmetic calculator has been developed to accompany this handbook. This is available from:

> http://www.brixtonhealth.com/fuzzy.html

The calculator is a web-based application and can be run over the Internet or the HTML file can be downloaded and run in a web browser without access to the Internet and looks like this:

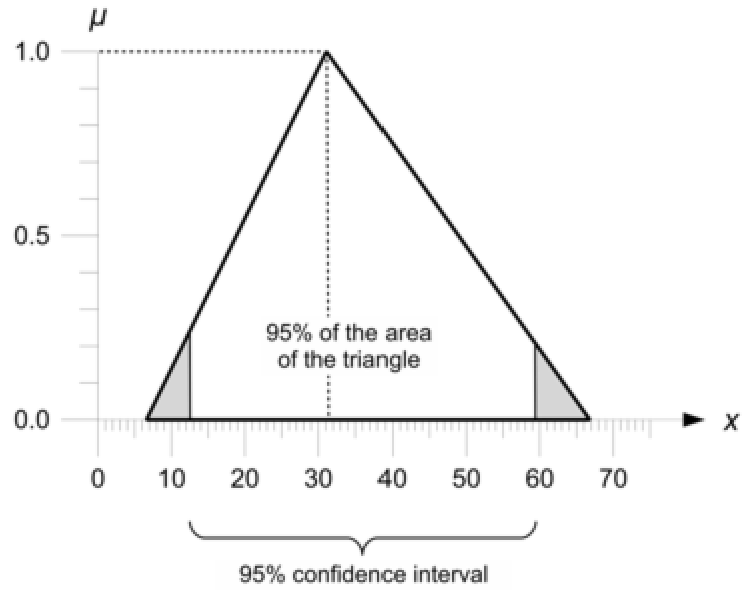


DALY calculations using fuzzy numbers

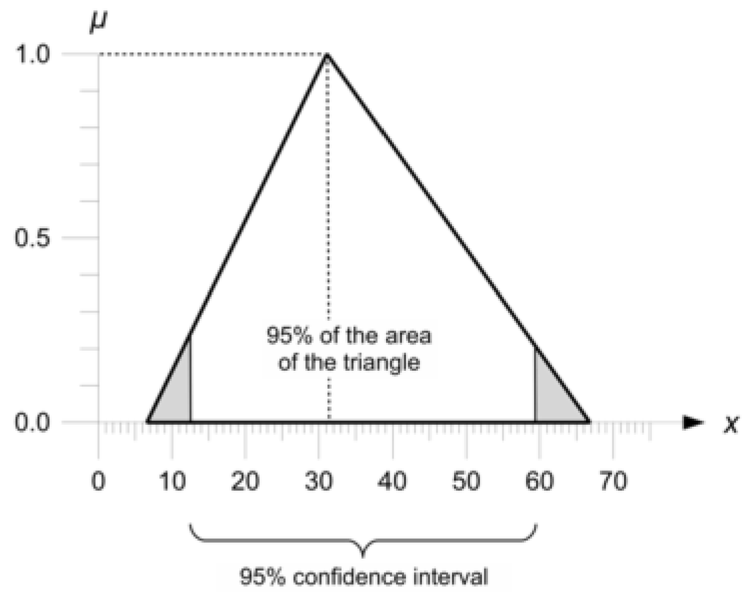
DALY calculations with fuzzy numbers follow those done with real numbers. Calculations are chained together to reach the final results.

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 very nearly all, possible / probable values of the quantity of interest. We usually want to claculate present ***95% confidence intervals***.

Here is a 95% confidence interval for a triangular fuzzy number representing $\text{DALYs}_{\text{Averted}}$:



The 95% Confidence intreval:



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 are:

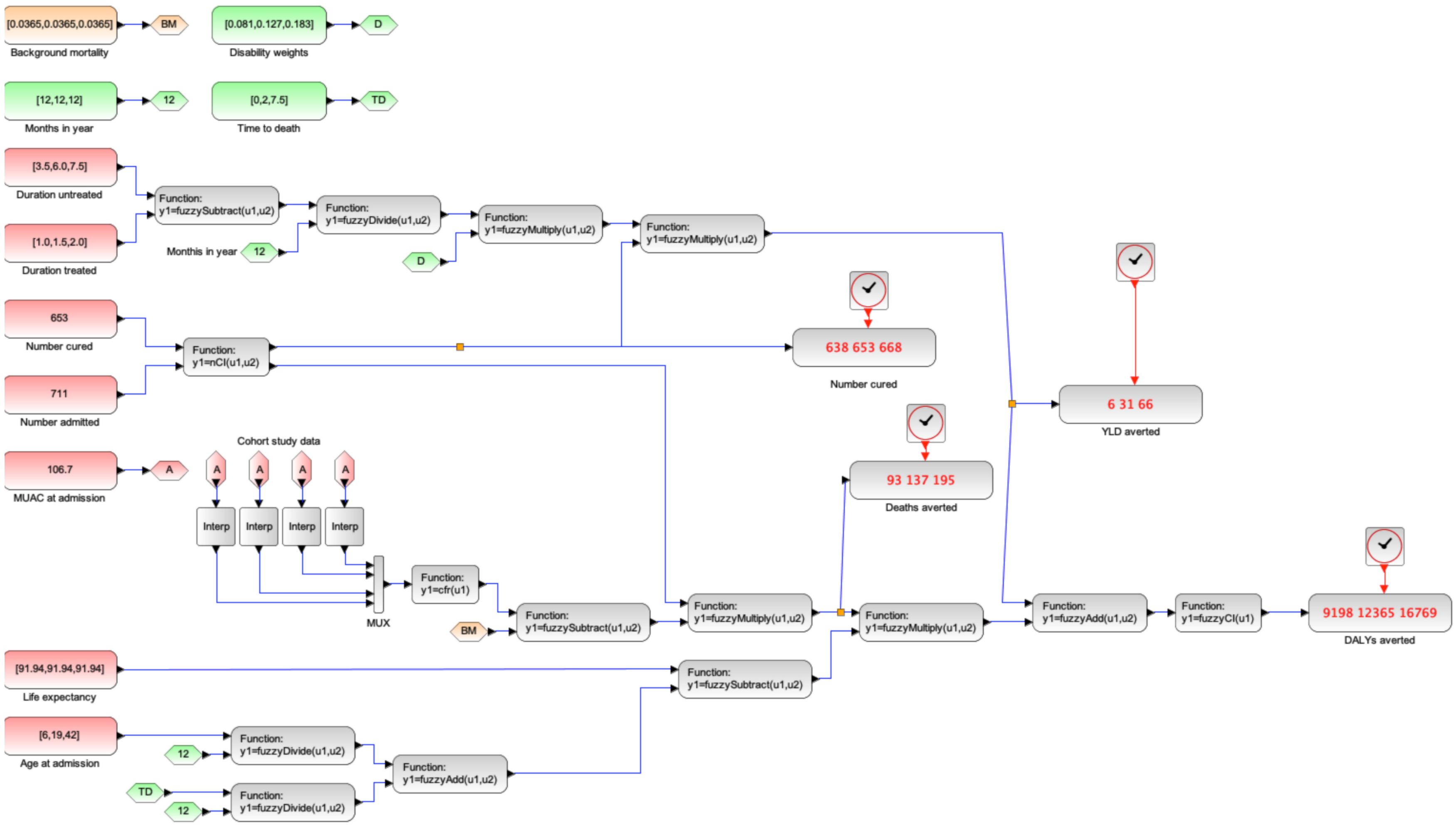
$$\textit{Lower}\ 95\ \textit{confidence limit} = a_1 + \sqrt{((a_3 - a_1) \times (a_2 - a_1) \times 0.025)}$$

$$\textit{Upper}\ 95\ \textit{confidence limit} = a_3 - \sqrt{((a_3 - a_1) \times (a_3 - a_2) \times 0.025)}$$

These 95% confidence intervals are also calculated by the fuzzy arithmetic calculator.

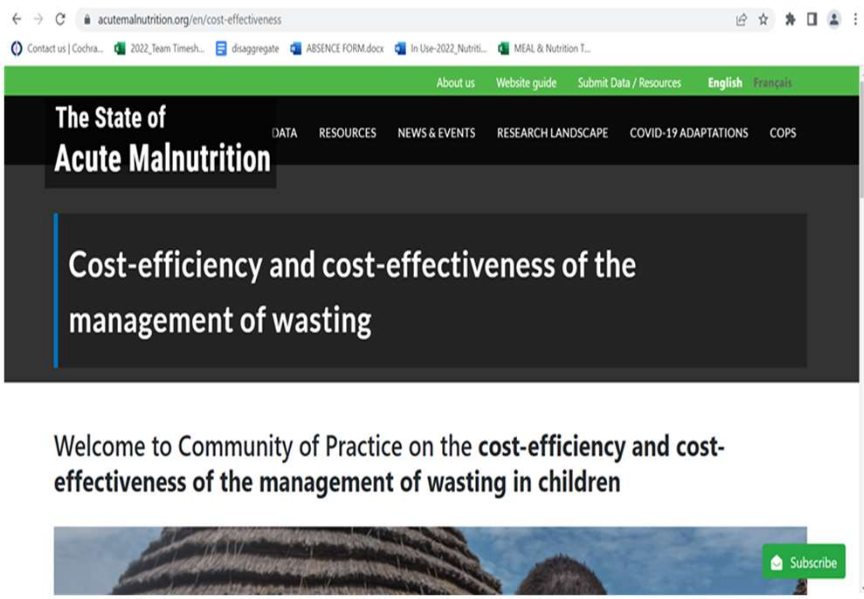
An alternative calculator

A graphic ”dataflow” calculator for DALY calculations using fuzzy traingular numbers has also been developed using SciLab:



LIVE “playground” demo coming very soon!

Child wasting costing and cost-effectiveness working group



https://acutemalnutrition.org/en/cost-effectiveness

- Webpage for information sharing under construction
- Tools, guidance available evidence
- Link to ENN Forum

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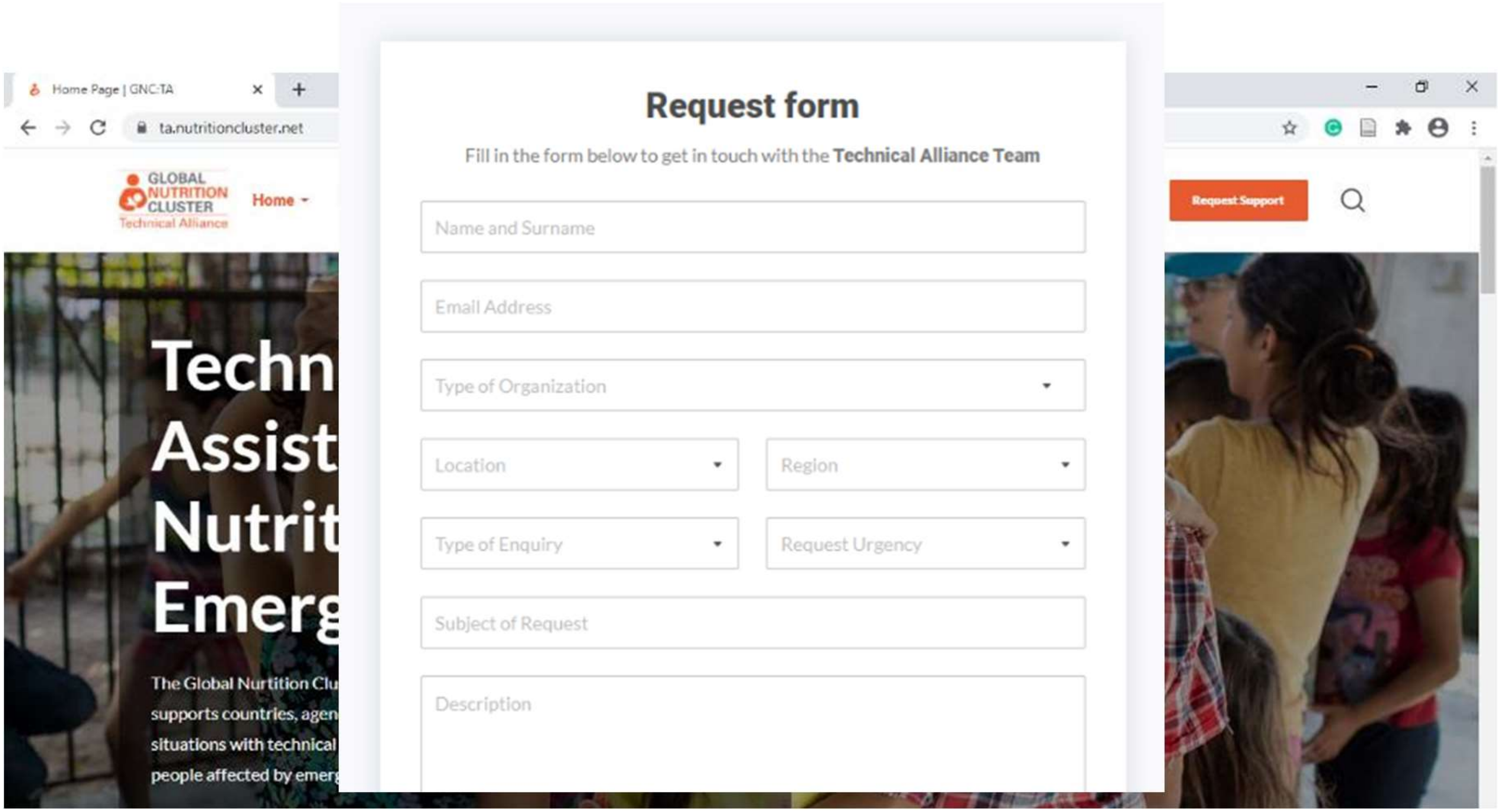

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THANK YOU!