

# MUAC vs. WHM : Screening, survival, and response

Mark Myatt, Division of Epidemiology, Institute of Ophthalmology, University College London

## How thin is thin?

Despite the accumulated evidence :

Low MUAC is associated with high mortality.

MUAC is more closely correlated with lean mass ratio than WHM.

A frequently repeated opinion regarding MUAC :

*“MUAC < 110 mm does not indicate exceptional thinness in emergency contexts and this is particularly true of younger children.”*

This begs the questions :

*“What is exceptional thinness?”*

Statistical definition :

**Any child more than 2 standard deviations below the mean MUAC<sup>†</sup> is exceptionally thin.**

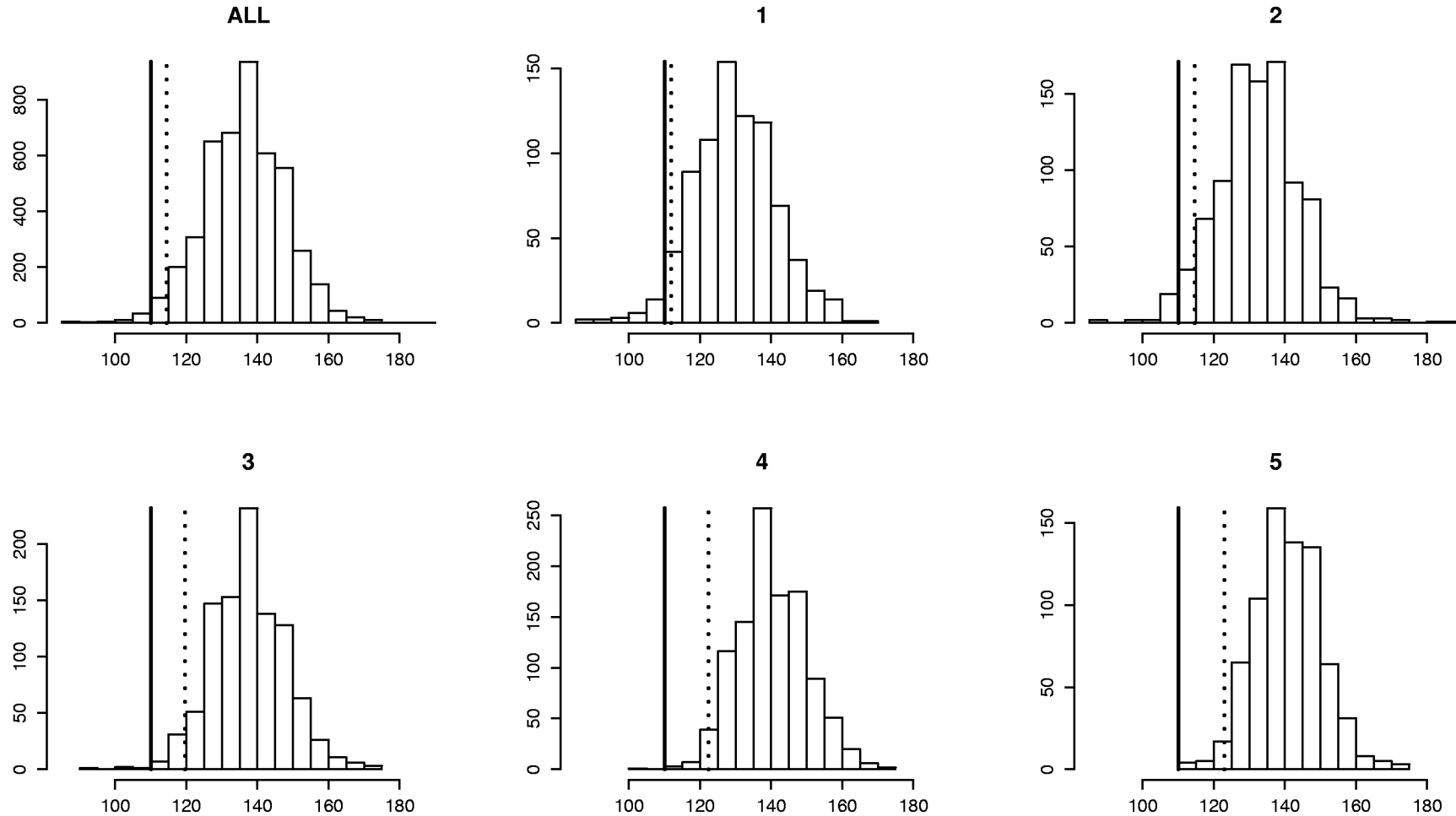
<sup>†</sup>Mean MUAC of the emergency-affected population **not** of a reference population.

Mean MUAC for 2 year-old children in South Wollo, Ethiopia in 2001-2003 (from five CONCERN WORLDWIDE nutritional anthropometry surveys) = 133 mm

Mean MUAC for 2 year-old children in England in 1998 (from UK Department of Health's *Health Survey for England 1998*) = 168 mm

# How thin is thin?

Distribution of MUAC by age in years seen in five surveys in South Wollo, Ethiopia 2001 – 2003 (n = 4562)



Solid line = 110 mm, Broken line = mean MUAC - 2 standard deviations

## Do low MUAC children belong in the OTP program?

Two questions :

1. Do low MUAC do well in SFP?

Mortality?

Weight gain?

If **yes**, then admitting low MUAC children into OTP is a waste of resources.

2. Do low MUAC children do well in OTP?

Mortality?

Weight gain?

If **no**, then admitting low MUAC children into OTP is a waste of resources.

# Triage

These questions are related to the concept of *triage* :

1. Not acutely undernourished ...

Do **not** admit

2. Acutely undernourished and will benefit from the program ...

Admit

3. Acutely undernourished but will not benefit from the program ...

Do **not** admit (they will die anyway!)

## Natural experiment (emergency context)

MUAC admission criteria for OTP (additional to the standard WHM and oedema criteria) for CONCERN CTC program in South Wollo, Ethiopia:

### **February 2003 (beginning of CTC) :**

MUAC < 110 mm and (age > 12 months<sup>†</sup> or height > 75 cm) :

High proportion of admissions on MUAC (89 out of 140 admissions in first month).

42 out of 89 patients admitted on MUAC < 110 mm with age > 12 months<sup>†</sup> but height < 75 cm.

### **March 2003 (on the strong advice of an international expert in malnutrition) :**

MUAC < 110mm and height > 75 cm :

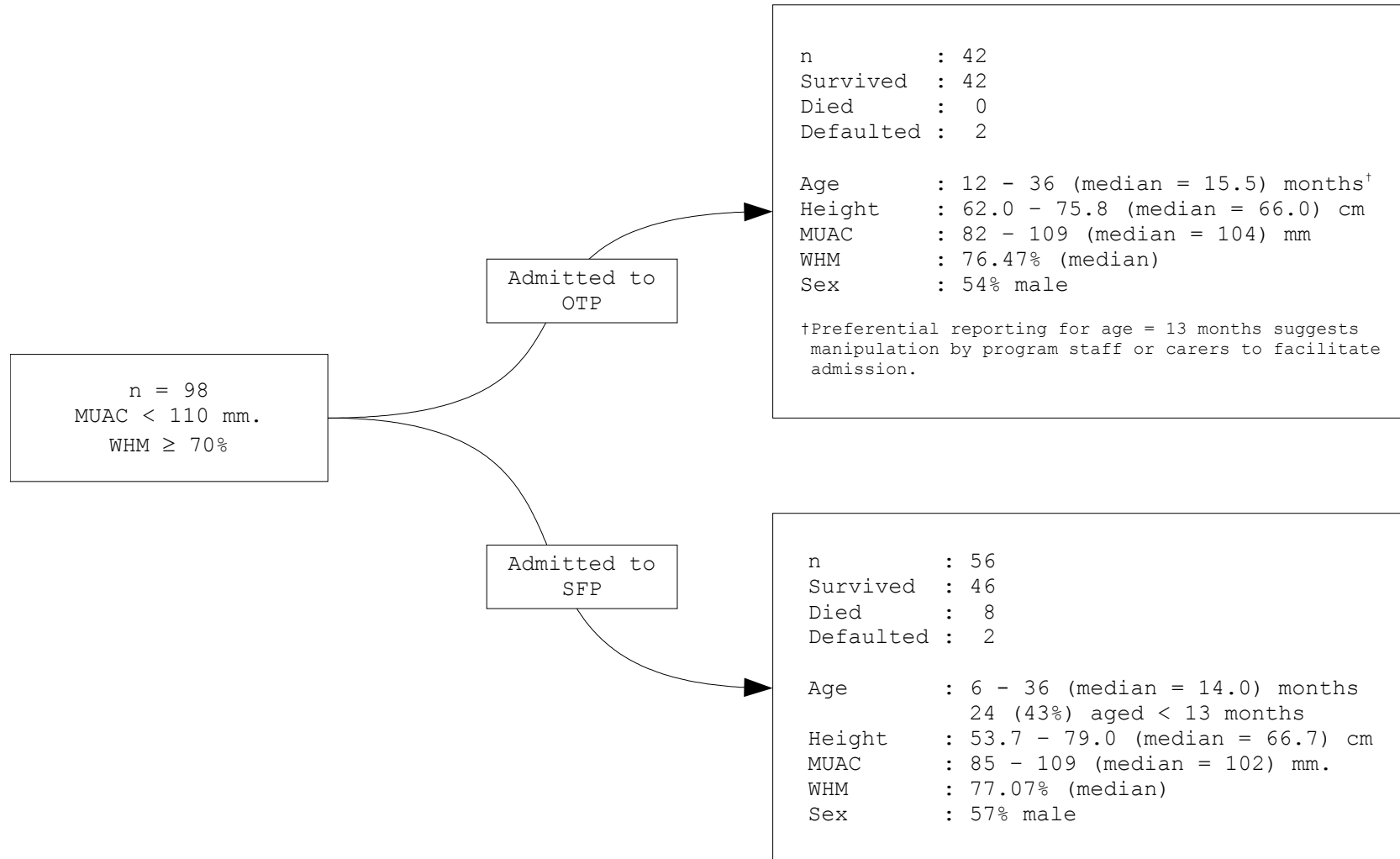
Children with MUAC < 110 mm and height < 75cm **not** admitted to OTP.

Low proportion of admissions on MUAC (3 out of 80 in month after change).

This enabled, in November 2003, a comparison of response of low MUAC children in OTP and SFP (i.e. before and after the change to admission criteria).

<sup>†</sup>Preferential reporting of age = 13 months suggest manipulation by program staff or carers to facilitate admission.

# Natural experiment (emergency context)



## Survival proportions in OTP and SFP for MUAC < 110mm and WHM ≥ 70%

		Outcome ...		
		Died	Survived	
Exposure :	SFP	8	46	54
	OTP	0	40	40
		8	86	94

Fisher-Irwin exact test : **p = 0.0094 (one sided)**  
 p = 0.0191 (two-sided)

Risk Difference : 14.81%, 95% CI = 3.15% - 26.47%  
 z-test : z = 2.17  
**p = 0.0149 (one-sided)**  
 p = 0.0299 (two sided)

The effect remains statistically significant after adjusting for age (i.e. age < 13 months vs. age ≥ 13 months) :

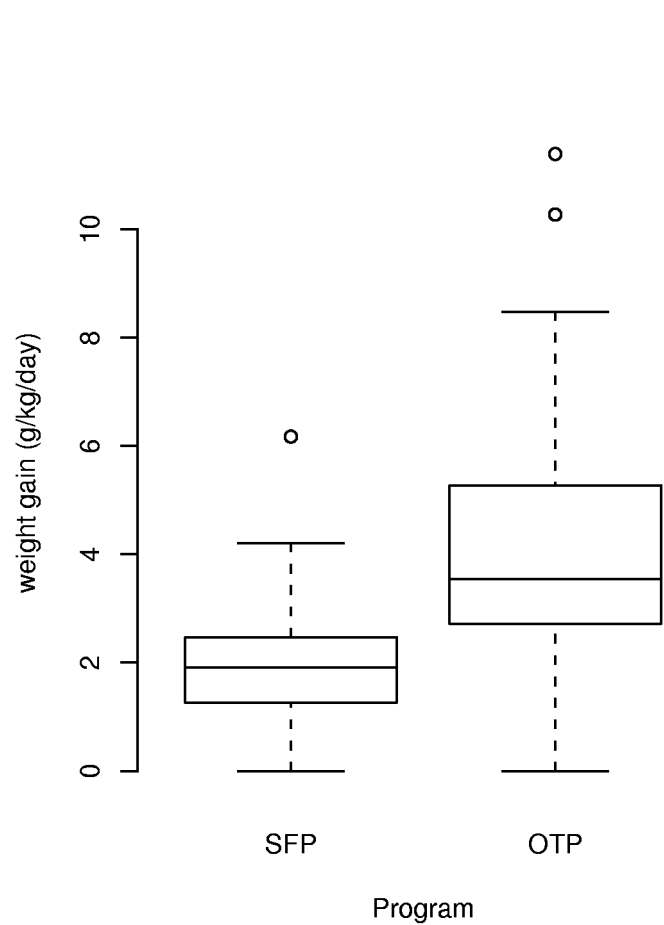
Mantel-Haenszel test :  $\chi^2 = 3.86$ , df = 1, **p = 0.0494**

This analysis is compromised by preferential (and unreliable) reporting of age. A better analysis is to adjust for height (as a proxy for age) at admission (i.e. above / below the overall median height at admission of 66.15 cm).

The effect remains statistically significant after adjusting for height at admission :

Mantel-Haenszel test :  $\chi^2 = 4.89$ , df = 1, **p = 0.0269**

# Weight gain (g/kg/day) in OTP and SFP for MUAC < 110mm and WHM ≥ 70%



## --- SFP ---

Sample size : 56

Mean weight gain (g/kg/day) : 1.89

Standard deviation : 1.13

Median weight gain (g/kg/day) : 1.90

## --- OTP ---

Sample size : 42

Mean weight gain (g/kg/day) : 4.28

Standard deviation : 2.44

Median weight gain (g/kg/day) : 3.55

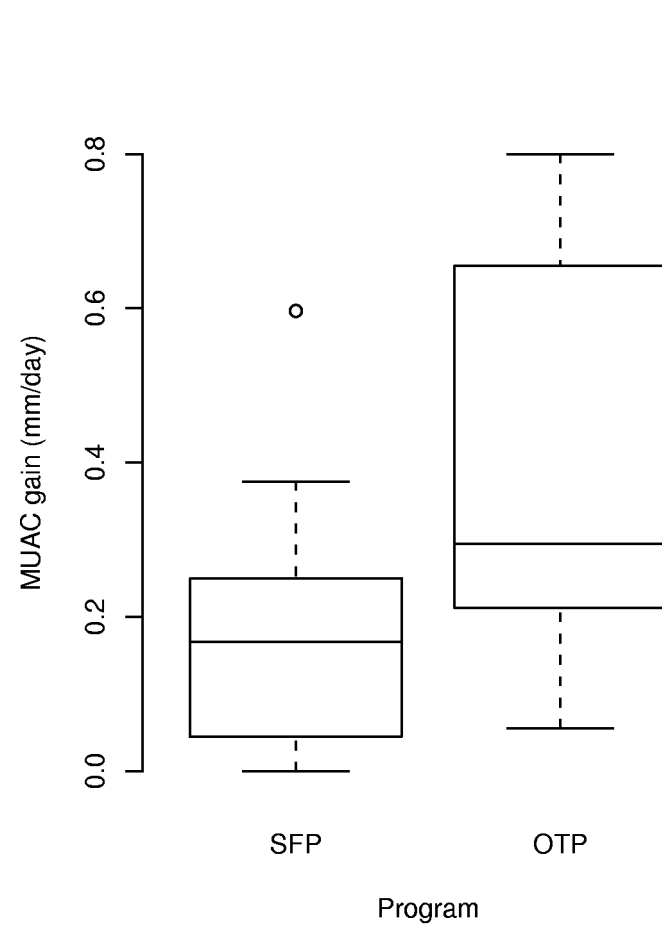
## --- Difference ---

Kruskal-Wallis Chi-square : 34.6714

df : 1

**p : 0.0000**

# MUAC gain (mm/day) in OTP and SFP for MUAC < 110mm and WHM ≥ 70%



## --- SFP ---

Sample size : 24

Mean MUAC gain (mm/day) : 0.17

Standard deviation : 0.16

Median MUAC gain (mm/day) : 0.15

## --- OTP ---

Sample size : 19

Mean MUAC gain (mm/day) : 0.40

Standard deviation : 0.25

Median MUAC gain (mm/day) : 0.30

## --- Difference ---

Kruskal-Wallis Chi-square : 8.9913

df : 1

**p : 0.0027**

Do low MUAC children belong in the OTP program in emergencies?

The data from the natural experiment shows :

**Low MUAC children do badly in SFP :**

Mortality is high (between 32 and 265 per 1000 children admitted).

Mean weight gain is  $< 2$  g/kg/day.

**Low MUAC children do well in OTP :**

Mortality is low (point estimate is zero).

Mean weight gain  $> 4$  g/kg/day.

Conclusion :

**Low MUAC children should be admitted to OTP rather than SFP.**

## Additional data (R2D Context)

Two hundred and forty six (246) admissions between 2<sup>nd</sup> December 2003 and 9<sup>th</sup> June 2004 with MUAC < 110 mm as the sole admission criteria (defaulters excluded).

Deaths : : 0

Weight gain :

Mean weight gain : 2.48 g/kg/day

Standard deviation : 1.62

Median weight gain : 2.13 g/kg/day

MUAC gain :

Mean MUAC gain : 0.23 mm/day

Standard deviation : 0.13

Median MUAC gain : 0.20 mm/day

Non-recovery<sup>†</sup> : : 15 (6.1%)

<sup>†</sup> Patients not achieving discharge criteria after four months in program. Weight stable. All treatment options (e.g. home visits, hospitalisation) pursued.

## Additional data (R2D Context)

Both weight gain and MUAC gain found in this data are significantly **worse** (i.e.  $p < 0.0001$ ) than those found in the OTP arm of the natural experiment.

### Why the difference?

SFP had stopped and the alternative EOS (**E**xtended **O**utreach **S**trategy) program had not started so the family was **not** receiving a ration intended to minimise misdirection of RUTF to other family members (the *protection package* in emergency OTP).

R2D context is defined by improved food security ... higher proportion of children with complicated malnutrition (e.g. infection) admitted to OTP in R2D contexts compared to emergency contexts.

Frequency of contact had changed from weekly to fortnightly.

Limited ability to refer non-responders to SC / district hospital.

Limited ability to run formal health promotion sessions at patient contact.

Increased reliance on volunteers rather than outreach workers.

NGO supervision of the program had reduced.

**BUT** ... both weight gain and MUAC gain found in this data are significantly **better** from those found in the SFP arm of the natural experiment ( $p = 0.0102$  for weight gain;  $p = 0.0374$  for MUAC gain).

## Summary

The low mortality rate seen in the OTP emergency program is maintained in the R2D program.

Low MUAC children do very well (in terms of weight gain and MUAC gain) in OTP in emergency contexts.

Low MUAC children do less well (in terms of weight gain and MUAC gain) in OTP in R2D contexts where the program is less intensive and family support packages are not available.

**→ Low MUAC children should be admitted to OTP in both emergency and R2D contexts.**

## The other side of the coin

Thus far ...

It is clear that children with  $MUAC < 110$  mm should be in OTP.

It is **not** clear that children with  $MUAC > 110$  mm and  $WHM < 70\%$  should **not** be in OTP.

We might be “Robbing Peter to pay Paul” by :

Moving some high risk (low MUAC) admissions from SFP to OTP, and ...

Moving a *similar number* of *potentially* high risk (low WHM) admissions from OTP to SFP.

But ...

Is it a *similar number*?

Are the two groups at *similar risk*?

## The other side of the coin

Tested by *simulating* different program admission criteria :

Composite dataset :

> 200 nutritional anthropometry survey datasets :

> 210,000 children.

Prevalence summary :

Global acute malnutrition	:	11.7%
Moderate	:	9.1%
Severe marasmic	:	1.3%
Severe oedematous	:	1.3%

Prevalences based on WHZ and oedema.

## The other side of the coin

Simulate two program admission criteria by applying program admission criteria to the combined dataset :

### **WHM program admission criteria :**

(WHM < 70% AND MUAC < 125 mm<sup>†</sup>) OR OEDEMA

### **MUAC program admission criteria :**

MUAC < 110 mm OR OEDEMA

<sup>†</sup>MUAC is present in the WHM program admission criteria as the first stage of screening.

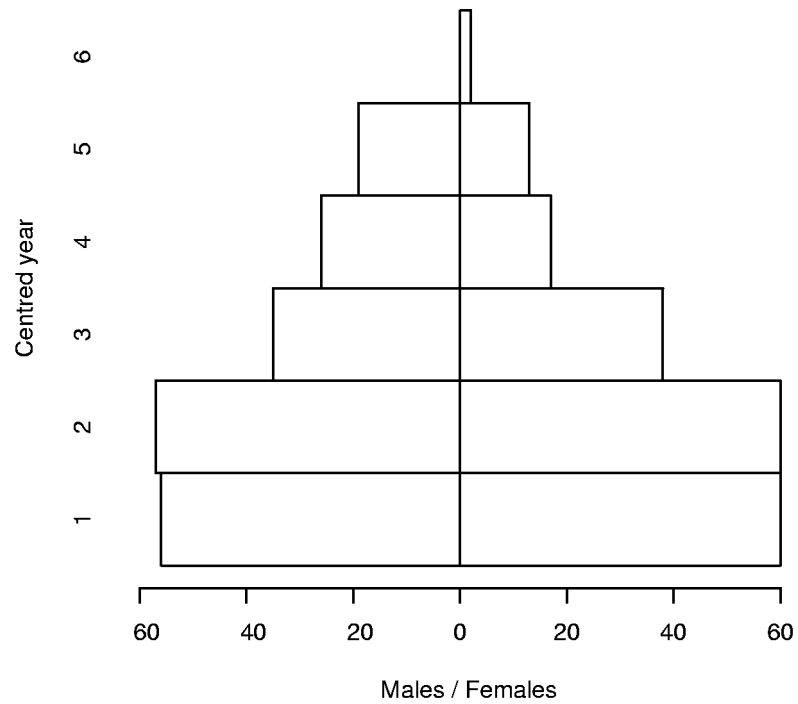
## The other side of the coin



Total program sizes : WHM = 3678; MUAC = 5484; BOTH (estimated need) = 5867

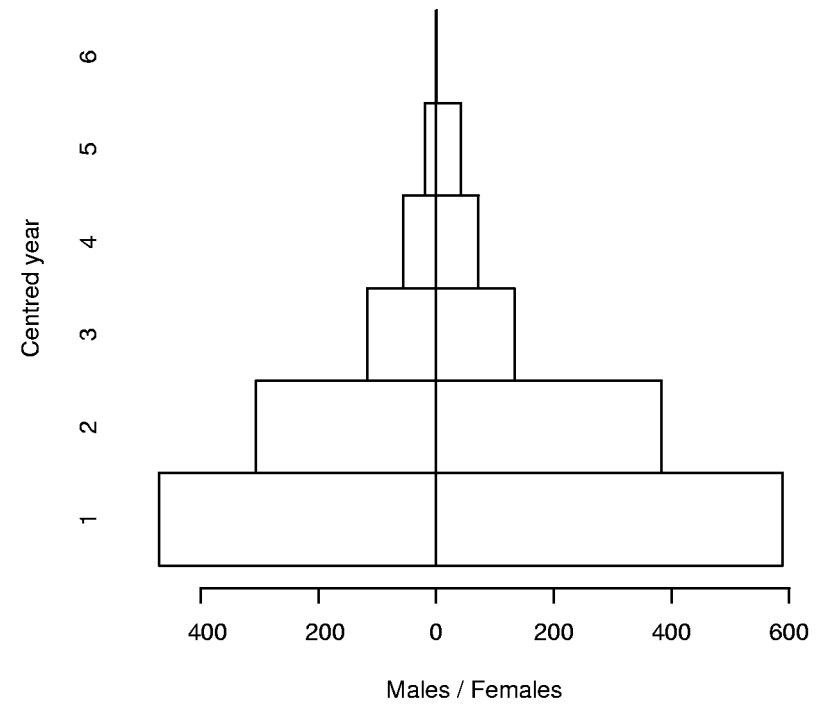
# The other side of the coin

Included by WHM but excluded by MUAC



Sample size : 383  
Median age (months) : 24

Included by MUAC but excluded by WHM



Sample size : 2189  
Median age (months) : 18

Kruskal-Wallis Chi-square = 34.6714, df = 1, **p = 0.0000**

## The other side of the coin

MUAC and WHM select many of the same children.

Changing admission criteria does “Rob Peter to pay Paul” but ...

When using MUAC, the number of excluded low WHM children is **small** relative to estimated need :

Estimated need (i.e. children identified by either MUAC or WHM)	:	5867	
At-risk children excluded by MUAC	:	383	(6.53%)

When using WHM, the number of excluded low MUAC children is **large** relative to estimated need :

Estimated need (i.e. children identified by either MUAC or WHM)	:	5867	
At-risk children excluded by WHM	:	2189	(37.31%)

The age-profile of the excluded low WHM children is different from the age-profile of the included low MUAC children. The excluded low WHM children are likely to be at lower risk than the included low MUAC children.

Combined with the mortality estimate (i.e. 14.81% for low MUAC children in SFP) from the natural experiment :

Low MUAC children excluded by WHM criteria	:	2189	
Estimated number of deaths in excluded low MUAC children	:	324	

Mortality in the excluded low WHM group would need to be 856 / 1000 admission to yield a similar number of deaths.

## Strong interface to the rescue!

We can exploit the strong interface that exists between OTP and SFP in CTC programs :

We use a banded MUAC strap which generates two types of referral :

MUAC < 110 mm → OTP

MUAC ≥ 110 mm and < 125 mm → SFP

Kids entering programs are weighed and measured.

If an SFP referral has MUAC ≥ 110 and WHM < 70% then they are admitted to OTP :

MUAC < 110 mm OR OEDEMA OR (WHM < 70% AND MUAC < 125 mm)

This procedure removes the problem of excluding low WHM but high MUAC children.

## Where there is no SFP

If there is no SFP then CTC admissions are based upon :

$$\text{MUAC} < 110 \text{ mm OR OEDEMA} = 1$$

Admissions are into OTP only.

There is no SFP to identify high MUAC but low WHM children so ... these children are excluded.

This is likely to be a problem only in non-emergency contexts but in these contexts :

There are likely to be other programs targeted at vulnerable households and communities.

Existing service providers may refer into OTP.

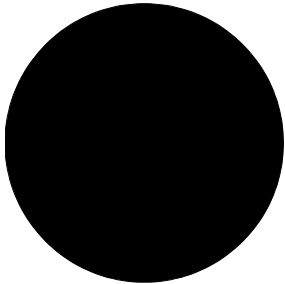
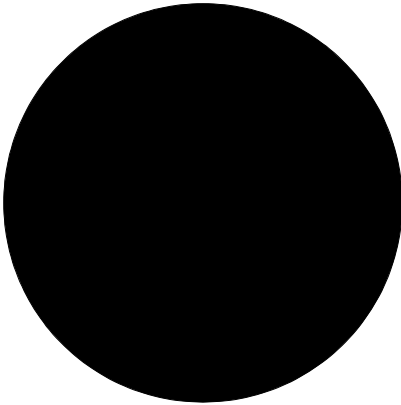
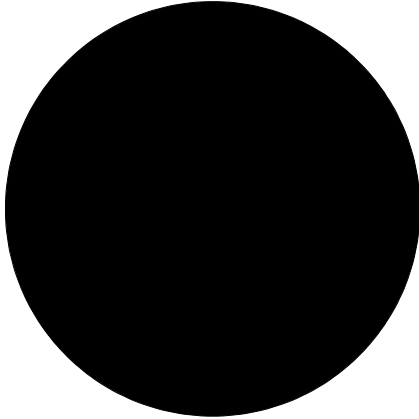
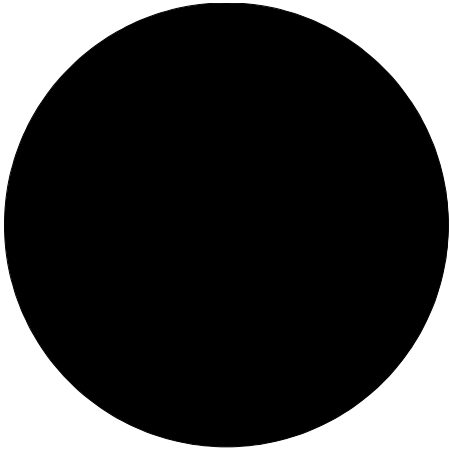
In transition contexts when SFP has ceased operation :

Outreach workers / CNVs operate a *watch-list* system.

Outreach workers / CNVs refer children they have concerns about.

## Implications for program size

MUAC programs will be larger than WHM programs ... simulation results :

WHM-based	Composite (age / height limited)	MUAC-based	Composite (WHM corrected)
<i>(WHM &lt; 70% and MUAC &lt; 125 mm) or OEDEMA</i>	<i>(WHM &lt; 70% and MUAC &lt; 125 mm) or (MUAC &lt; 110 mm and (HEIGHT &gt; 75 cm or AGE &gt; 12 months) or OEDEMA</i>	<i>MUAC &lt; 110 mm or OEDEMA</i>	<i>MUAC &lt; 110 mm or (WHM &lt; 70% and MUAC &lt; 125 mm) or OEDEMA</i>
			
3678	5261	5484	5867
Large coverage penalty	Small coverage penalty	No coverage penalty	No coverage penalty

## An additional issue

If we move to admission on MUAC we will :

Admit on MUAC

Discharge on WHM but ...

... some low MUAC children arrive above the discharge criteria!

This raises the question ...

# Is it possible to discharge on MUAC?

## Discharge criteria for low MUAC but high WHM patients

Current practice in low MUAC but high WHM admissions :

Discharge as *cured* after a minimum of two months in OTP if MUAC > 110 mm and evidence of sustained weight gain and patient is “clinically good”.

Discharge as a *non-responder* after a minimum of four months in OTP if weight is stable and all available treatment options (e.g. home visits, inpatient stabilisation, hospitalisation) have been pursued.

It *may* be possible to both admit and discharge all patients on MUAC, for example :

Admission criteria	:	MUAC < 110 mm
Discharge criteria ( <i>cured</i> )	:	MUAC ≥ 125 mm

An example (using information for the natural experiment) :

Admission MUAC	:	105 mm
MUAC gain	:	0.25 mm / day
Days in program	:	$(125 - 105) / 0.25 = 80$ days

Discharge criteria for *non-response could* be (e.g.) :

Discharge as a *non-responder* after a minimum of four months in OTP if MUAC is stable and all available treatment options (e.g. home visits, inpatient stabilisation, hospitalisation) have been pursued.

## An alternative to MUAC and WHM as a discharge criteria

An alternative to both MUAC and WHM as a discharge criteria could be *percentage increase in weight* :

$$[(\text{current weight} / \text{admission weight}) - 1] * 100)$$

Advantages :

Removes the need to measure height and calculate WHM.

Less radical than switching to MUAC.

Potential problems :

Height gain during treatment may lower WHM during treatment ... may be a problem with :

In OTP where duration of treatment may be two to three times that in TFC.

Younger children (preferentially selected by MUAC).

Available evidence indicates that height gain tends to occur **after** substantial weight gain. Also, there is no evidence that WHM is a *gold standard* for recovery.

Kwashiorkor patients have non-linear weight trajectories (i.e. weight is shed as oedema / ascites is lost) :

May be solved by using *lowest weight* in preference to *admission weight*.

**Further work is required to derive MUAC and percentage increase in weight benchmarks for discharge criteria that does not rely on height measurement and to decide between them ... can be done with existing program data.**

## Conclusions

Low MUAC children should be in OTP :

- Low mortality.
- Acceptable weight gains.

Exclusion of some children with WHM  $< 70\%$  :

- Small numbers.
- Not a problem in emergency contexts (referrals on WHM from SFP).
- Problem can be ameliorated in non-emergency contexts.

Program size :

- Larger programs but ...

- Better targeted at those at highest risk.
  - CTC does not have same capacity limits as TFC.
  - Cost per patient cured reduces with larger programs due to high fixed costs.

## Conclusions

Discharge and monitoring criteria :

Possible to move towards a MUAC-based discharge criteria?

Possible to move towards monitoring using MUAC (good prognostic indicator)?

Possible to move towards percentage increase in weight as a discharge criteria?

Can this be done?

Further analysis of existing data required.

Which (i.e. MUAC or percentage increase in weight) is best?

Further analysis of existing data required.

Sundry :

Need to collect MUAC and report prevalence by MUAC and oedema in anthropometric needs assessment surveys.

# Acronyms

The following acronyms were used in this presentation:

<b>CNV</b>	Community Nutrition Volunteer
<b>CTC</b>	Community Therapeutic Care
<b>EOS</b>	Extended Outreach Strategy
<b>MUAC</b>	Mid-upper-arm-circumference
<b>NGO</b>	Non Governmental Organisation (Private Voluntary Organisation)
<b>OTP</b>	Outpatient therapeutic care
<b>R2D</b>	Relief to development
<b>SC</b>	Stabilisation centre
<b>SFP</b>	Supplementary Feeding Program
<b>TFC</b>	Therapeutic Feeding Centre
<b>WHM</b>	Weight for height percentage of median
<b>WHZ</b>	Weight for height z-score