



Sierra Leone Four Foods Moderate Acute Malnutrition (MAM) Treatment Study: Findings and Implications

28 August 2019
Washington, DC

Is there any single food that we should be programming for MAM treatment?

Malian children with moderate acute malnutrition who are treated with lipid-based dietary supplements have greater weight gains and recovery rates than those treated with locally produced cereal-legume products: a community-based, cluster-randomized trial¹⁻⁵

Robert S Ackatia-Armah, Christine M McDonald, Seydou Doumbia, Juergen G Erhardt, Davidson H Hamer, and Kenneth H Brown

A novel fortified blended flour, corn-soy blend “plus-plus,” is not inferior to lipid-based ready-to-use supplementary foods for the treatment of moderate acute malnutrition in Malawian children¹⁻⁵

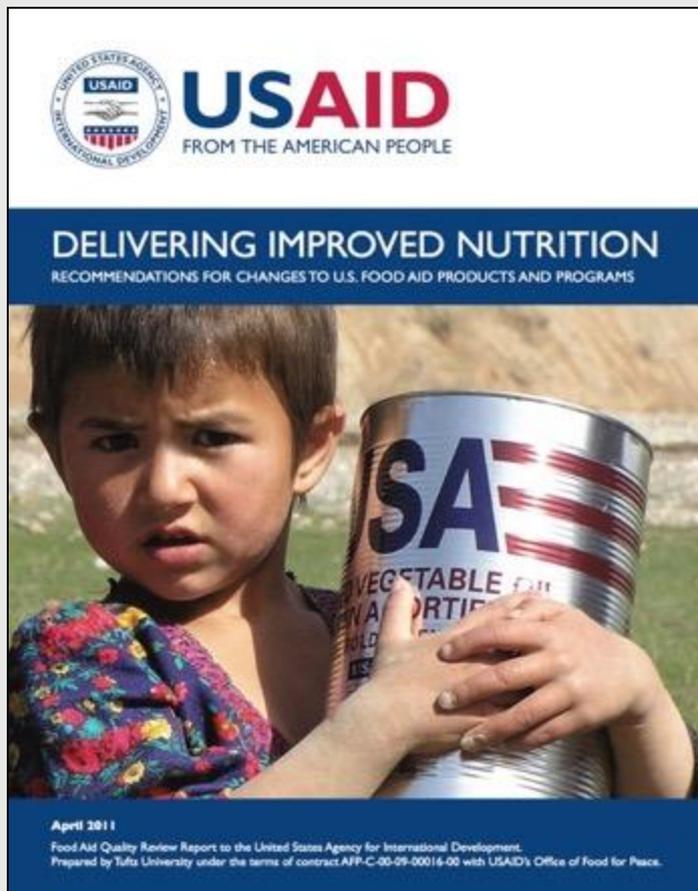
Lacey N LaGrone, Indi Trehan, Gus J Meuli, Richard J Wang, Chrissie Thakwalakwa, Kenneth Maleta, and Mark J Manary

Specially formulated foods for treating children with moderate acute malnutrition in low- and middle-income countries

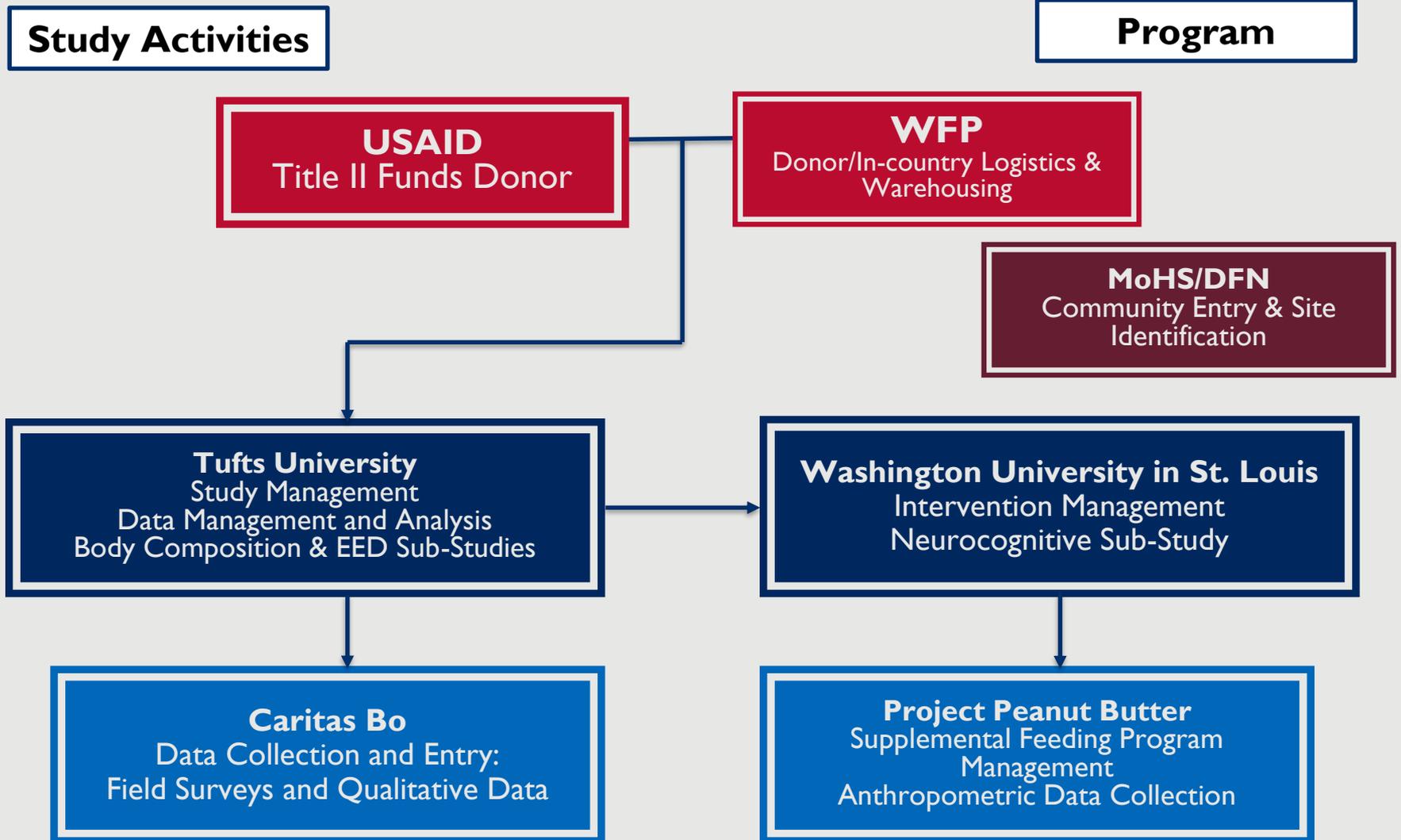
“There is no definitive consensus on the most effective way to treat children with moderate acute malnutrition.”

Food Assistance for Nutrition: The Food Aid Quality Review (FAQR) Project

- Is food aid 'fit for purpose?'
- Food is only part of the puzzle!



The Four Foods MAM Treatment Study worked with many different partners



Today's Agenda



Introduction and Background: The Four Foods MAM Treatment Study



Results of Main Study

- Comparative Effectiveness
- Cost-effectiveness
- Behavioral Factors Influencing Effectiveness



Three Sub-Studies

- Environmental Enteric Dysfunction
- Body Composition
- Neurocognition



Implications for FFP Programming



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The Four Foods MAM Treatment Study: Our Aims

- **Compare effectiveness:** determine whether there are differences in recovery among children with MAM treated with one of four supplementary foods
- **Compare cost-effectiveness:** Assess program costs among the four study arms and use these costs to determine the cost effectiveness of each supplement in terms of ‘cost per recovered child’
- **Identify behavioral factors that may influence effectiveness:** Discern intervention components, including ration collection, preparation, consumption, sharing, and selling behaviors



Photo credit: FAQR. Caregiver during demonstration section of in-depth interview

We also conducted three separate sub-studies that considered additional measures of recovery

Rationale: Current anthropometric measures (z-scores, MUAC) used in intervention studies are incomplete measures of recovery

1. Body Composition

- Fat and fat-free mass accretion during nutritional interventions tell us more about quality of weight gain, and may be more predictive of long-term health outcomes

2. Environmental Enteric Dysfunction

- Changes in structure and function of small intestine (often due to chronic infection) are associated with malnutrition and may modify the response to nutritional interventions

3. Neurocognition

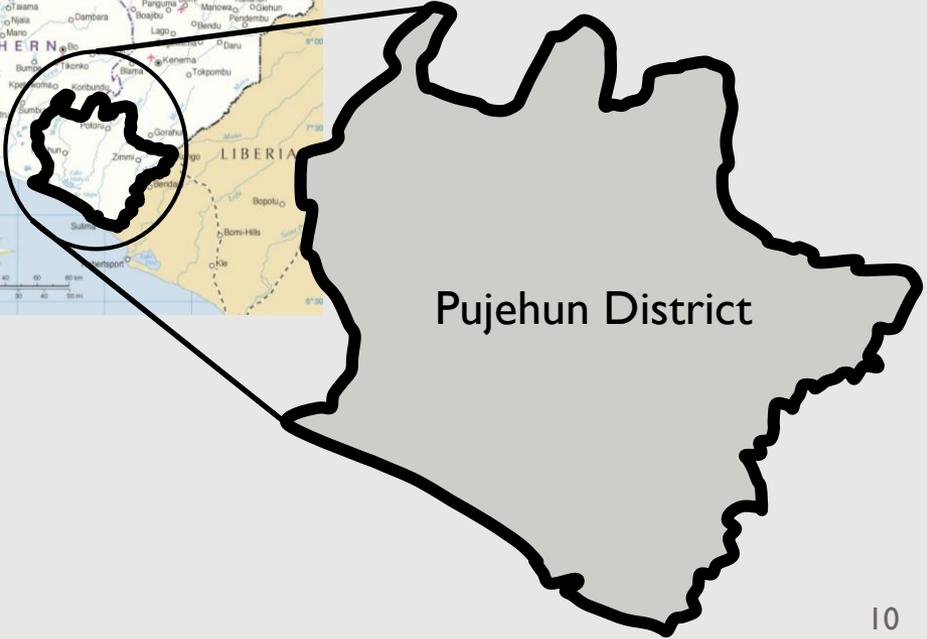
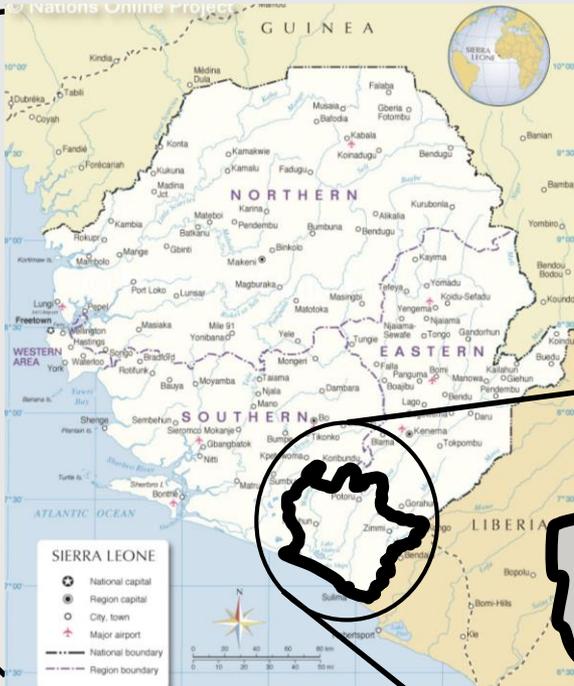
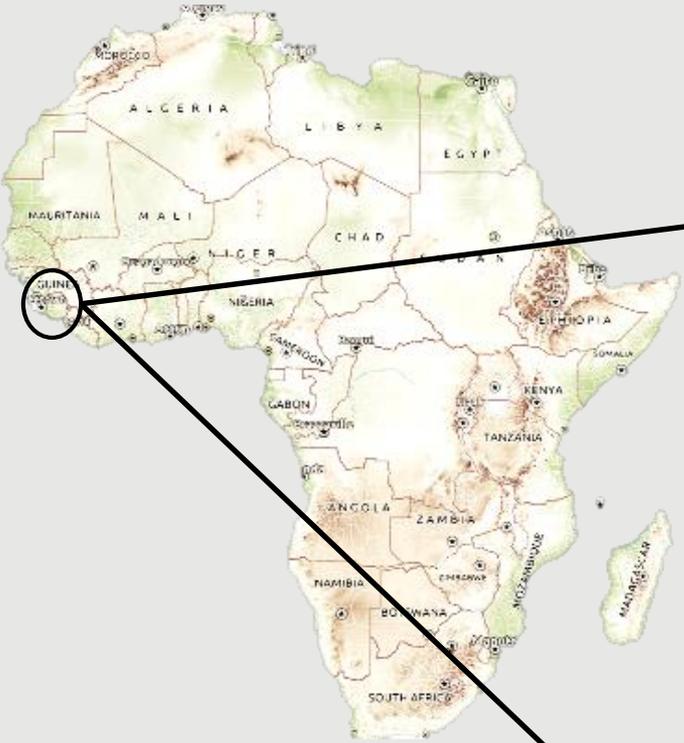
- Malnutrition affects cognitive development, so need to measure this directly in relation to “recovery”

What is different about each of the foods?

	CSB+ w/Oil	CSWB w/Oil	SC+ Amylase	RUSF
Fortified Blended Flour (FBF)	✓	✓	✓	
FVO Provided as Separate Ingredient	✓	✓		
Ready-to-Use				✓
Dairy Component (Milk or Whey)		✓	✓	✓
Novel Formulation		✓	✓	

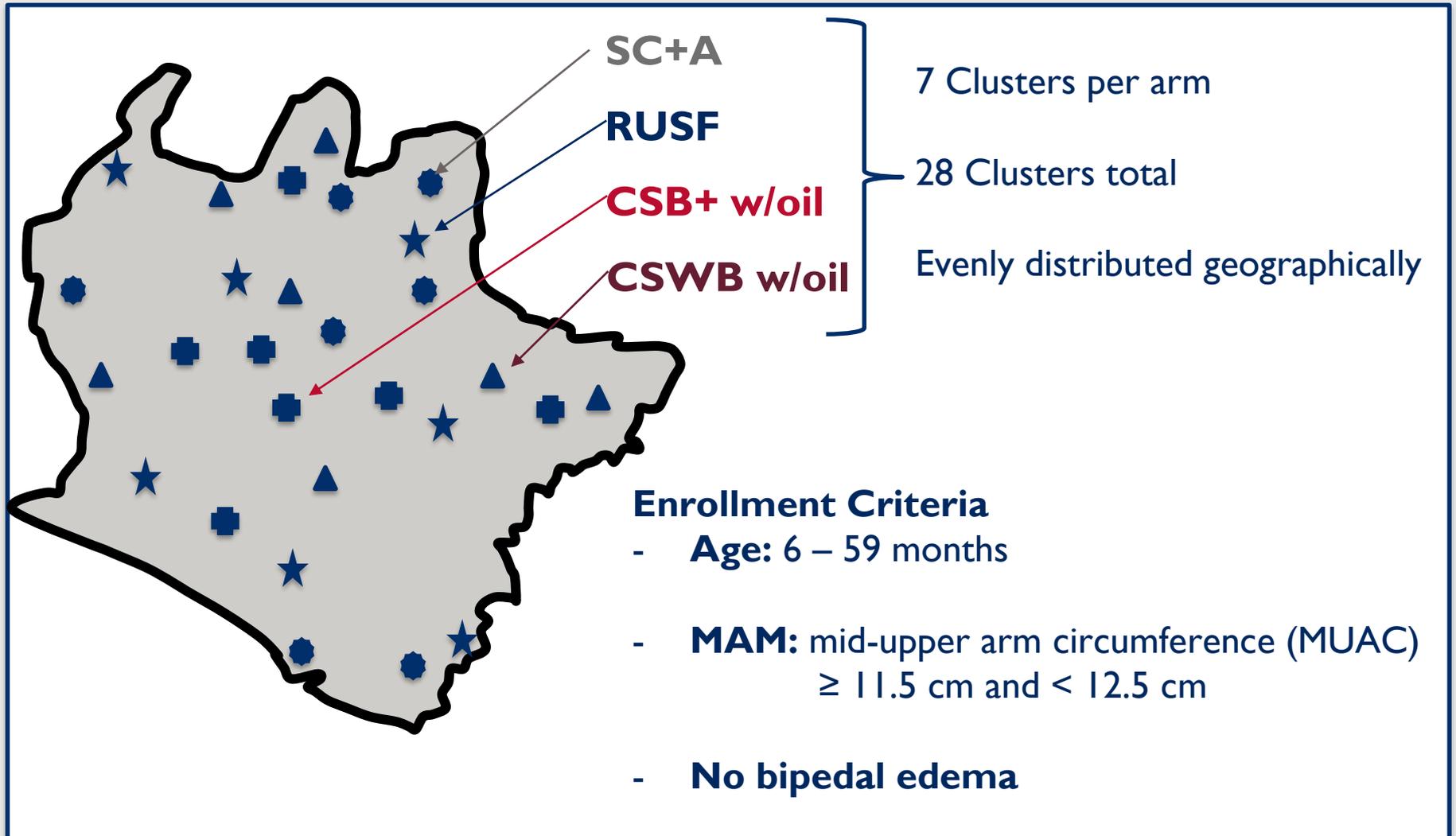
Isoenergetic Ration - 550kcal/day

Study Context: Southern Sierra Leone



Study Design: A Cluster-Randomized Effectiveness Trial

Each cluster = 1 peripheral health unit (“PHU”)



The Study's Intervention: Bi-weekly Mobile Clinic



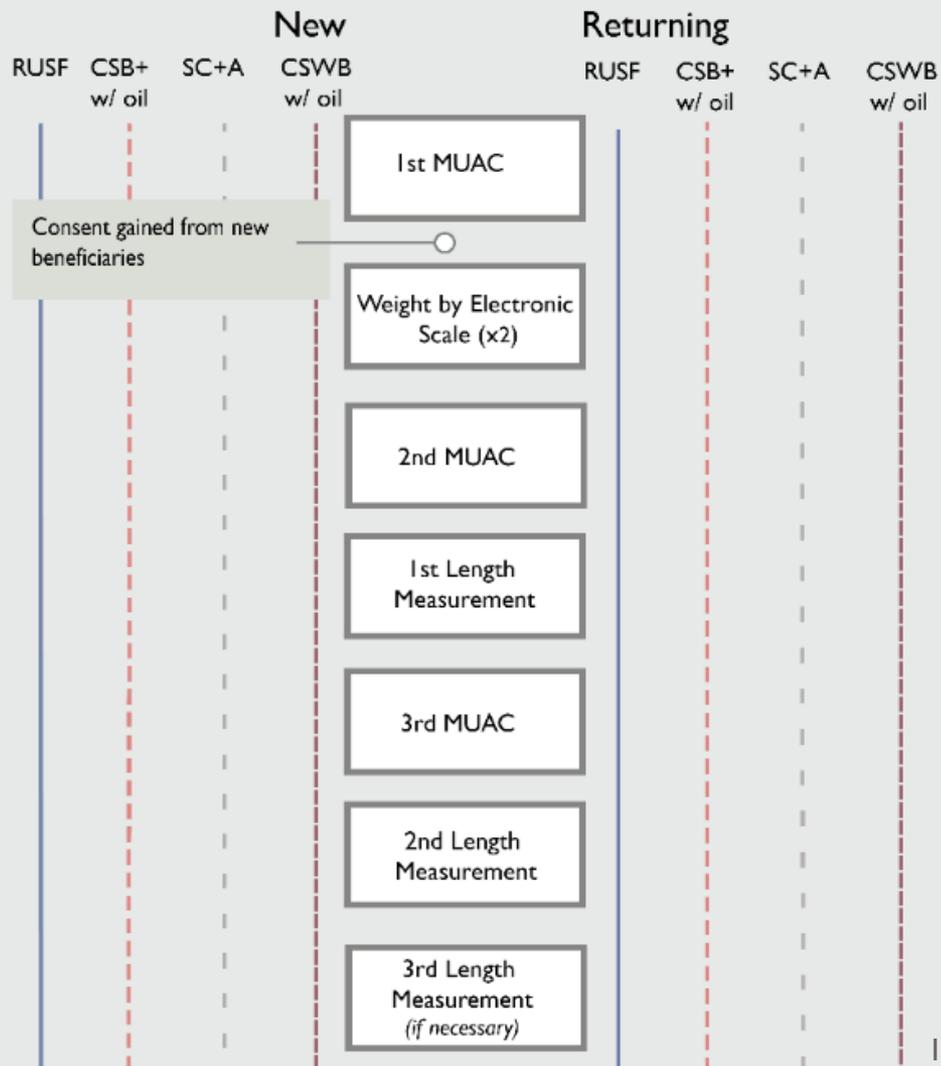
Photo credit: FAQR. Child receiving first MUAC



Beneficiaries arrive at the clinic
and await entry



Anthropometric Measurements

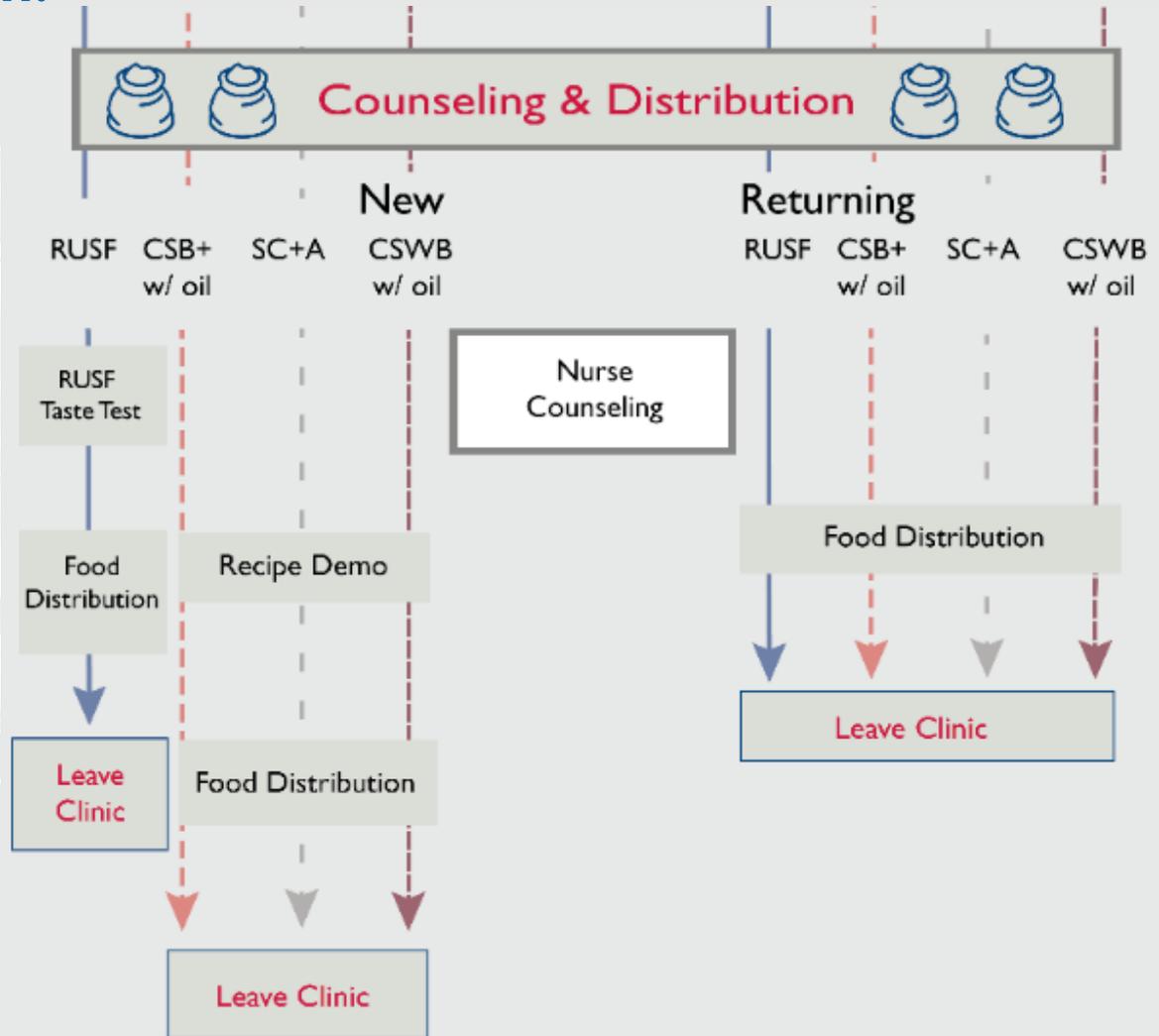


The Study's Intervention: Bi-weekly Mobile Clinic



Photo credit: FAQR. Caregiver receiving RUSF ration

Mobile Clinic Distribution Model

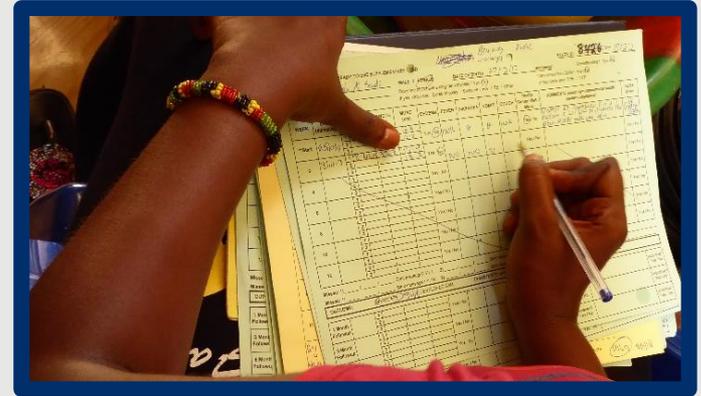


This process occurred every two weeks until the beneficiary exited the program

This is a mixed methods study with different subsamples



Quantitative:
Clinic Data
In-Depth Surveys



Quantitative/Qualitative:
In-Home Observations



Qualitative:
Focus Group Discussions





Introduction and Background: The Four Foods MAM Treatment Study



Results of Main Study

- Comparative Effectiveness
- Cost-effectiveness
- Behavioral Factors Influencing Effectiveness



Three Sub-Studies

- Environmental Enteric Dysfunction
- Body Composition
- Neurocognition

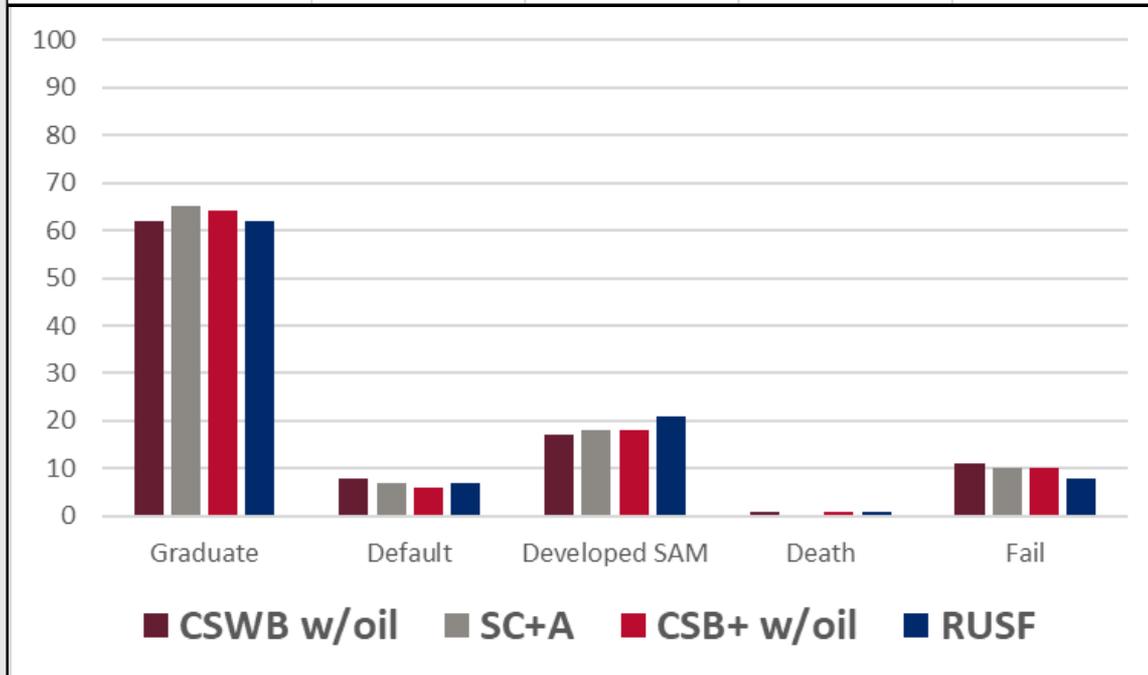


Implications for FFP Programming

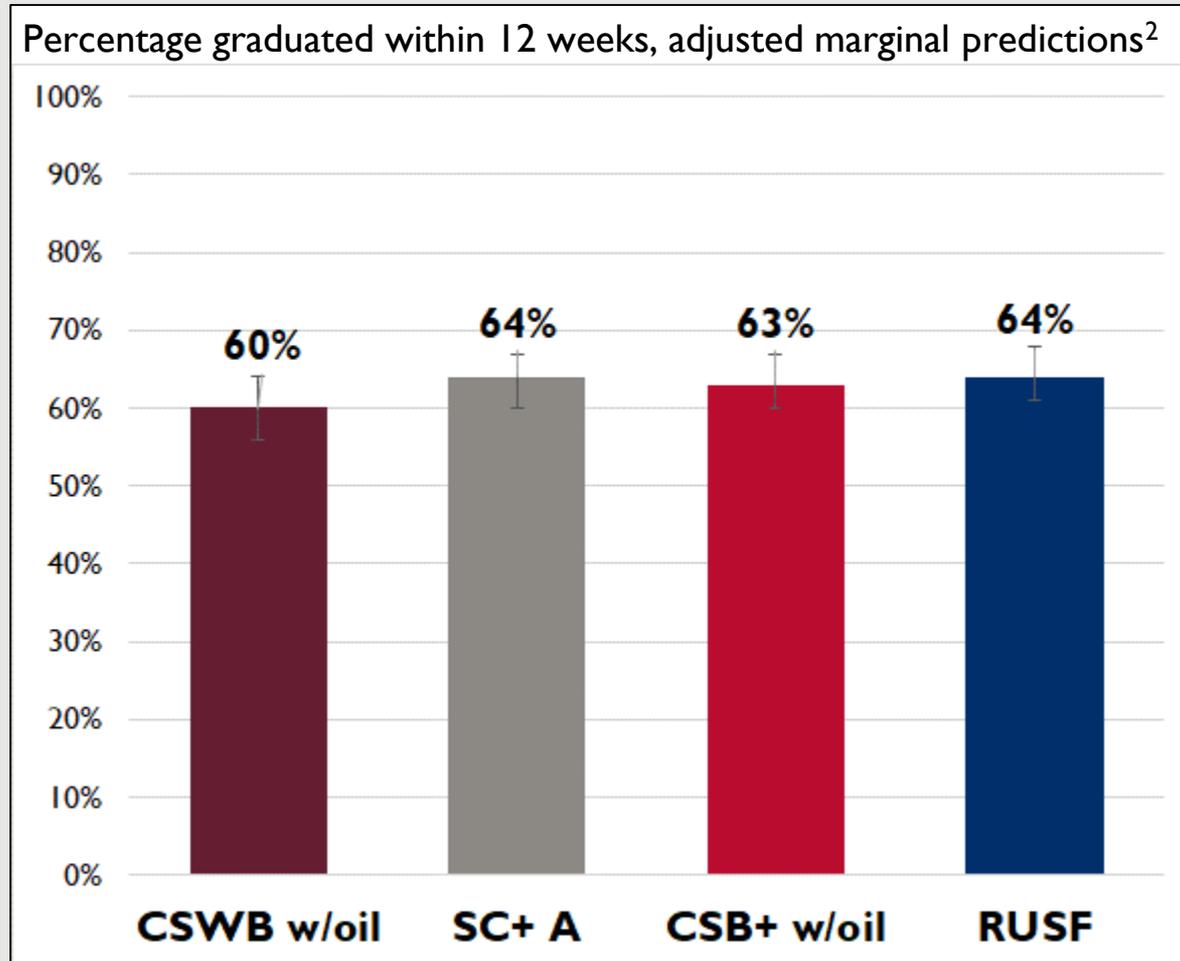
In crude analysis, outcomes were similar across arms

By food: percent of enrolled beneficiaries reaching each outcome

	CSWB		CSB+	
	w/oil	SC+ A	w/oil	RUSF
Graduate	62%	65%	64%	62%
Default	9%	7%	6%	7%
Developed SAM	17%	18%	18%	21%
Death	1%	0.30%	1%	1%
Fail	11%	10%	10%	8%



There was no difference in recovery rates among the foods in adjusted analysis¹



¹Factors in adjusted analysis: child's sex, child's age, breastfeeding, enrolled in rainy season, transferred from SAM, twin at birth, mother is caregiver, caregiver is married, caregiver's age, education level, HFIAS, and SES

²Error bars represent 95% Confidence Intervals

There were also no differences in odds of recovery among the foods in both crude and adjusted analysis¹

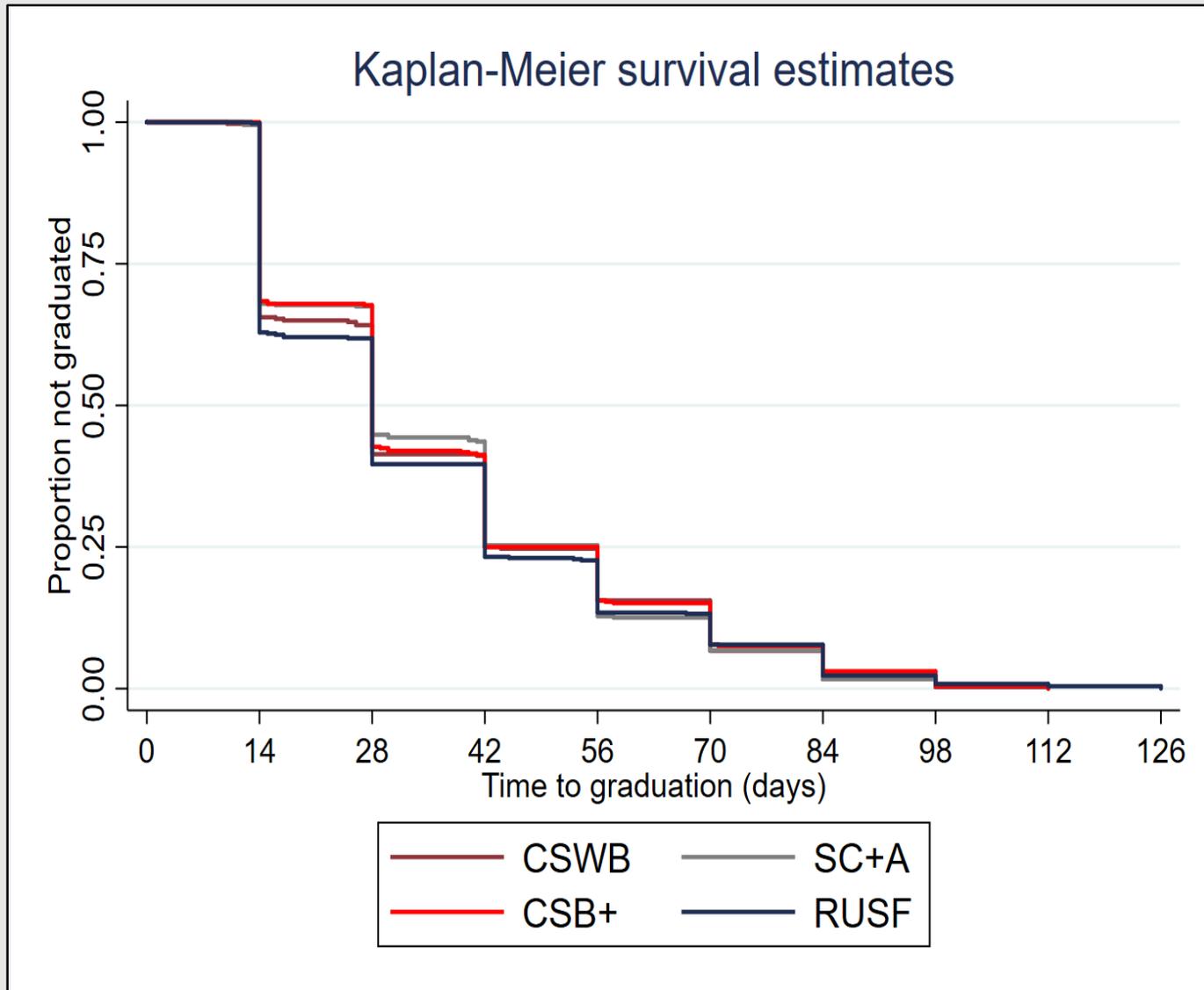
Crude and adjusted models, showing odds ratios among foods compared to CSB+ w/oil

	<u>Crude</u>			<u>Adjusted¹</u>		
	OR²	95% CI	P-value	OR²	95% CI	P-value
CSB+ w/ oil (ref.)						
CSWB w/ oil	0.93	(0.74, 1.17)	0.52	0.87	(0.67, 1.13)	0.30
SC+ w/a	1.05	(0.84, 1.32)	0.66	1.05	(0.82, 1.36)	0.69
RUSF	0.94	(0.76, 1.17)	0.59	1.1	(0.87, 1.40)	0.43

¹Factors in adjusted analysis: child's sex, child's age, breastfeeding, enrolled in rainy season, transferred from SAM, twin at birth, mother is caregiver, caregiver is married, caregiver's age, education level, HFIAS, and SES

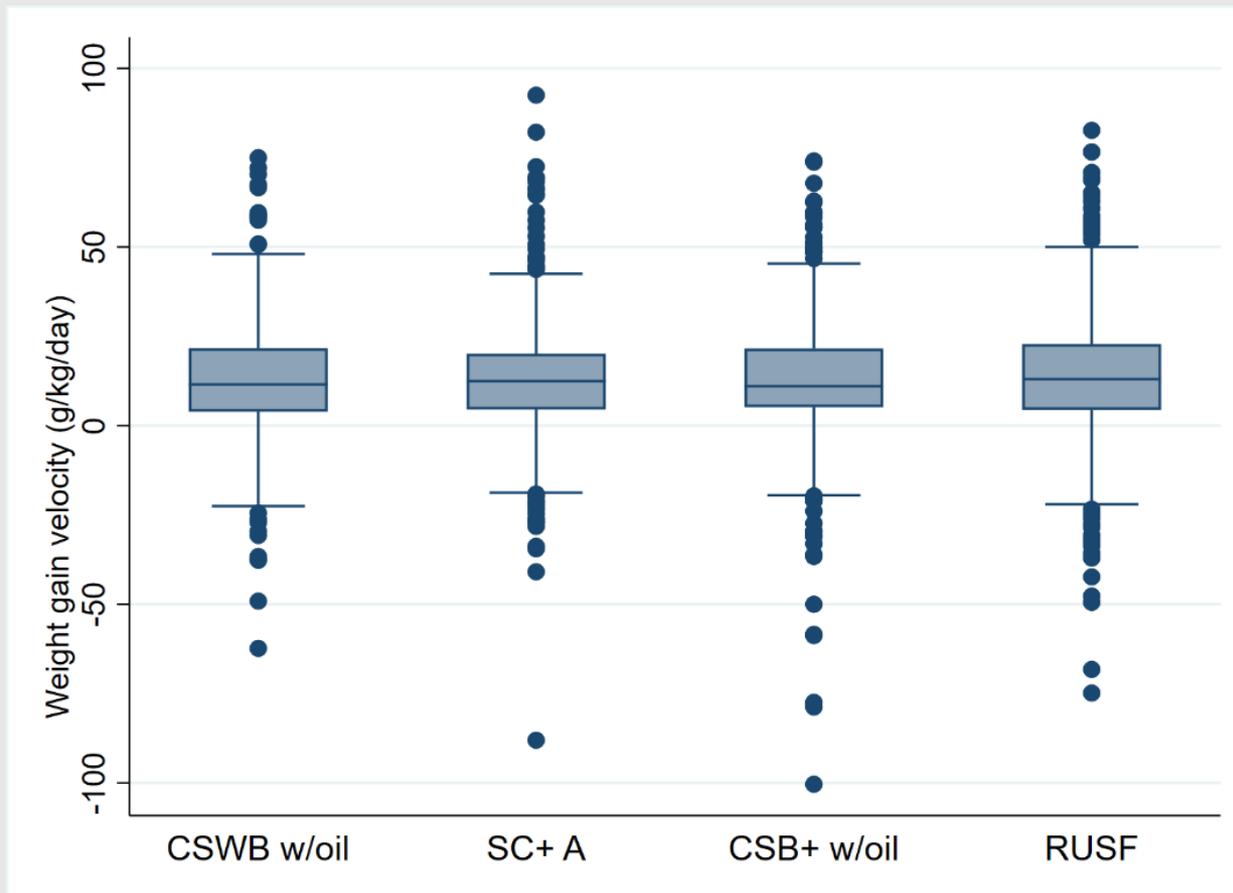
²Odds ratio: Odds of a child recovering from MAM compared to CSB+ w/oil

There were also no differences in time to graduation

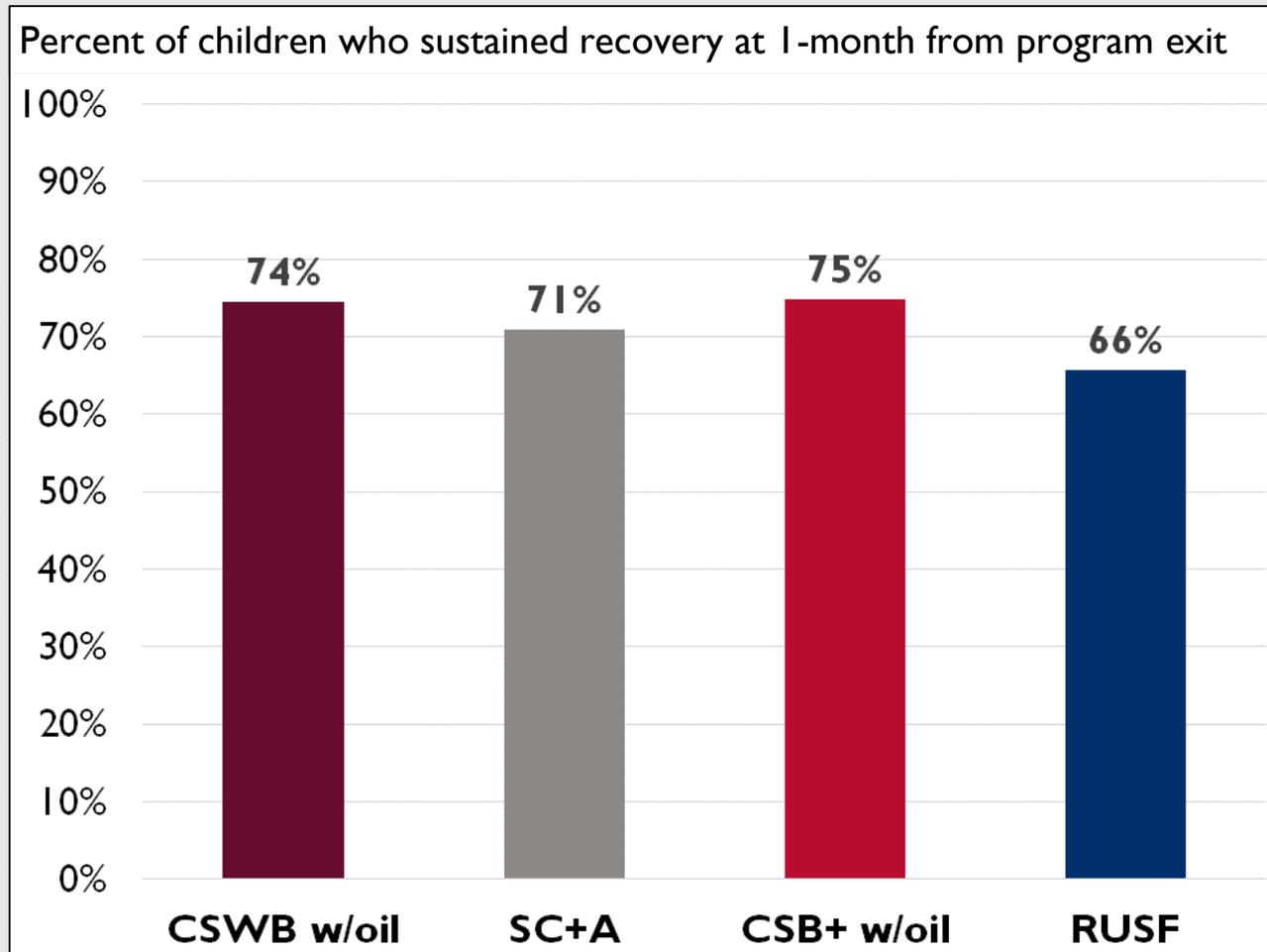


There were also no differences in weight gain velocity

	CSWB w/oil	SC+ A	CSB+ w/oil	RUSF
Weight gain velocity (g/kg/day)	12.8±16.5 (-62.3,75)	13±16.9 (-88,92.5)	12.6±17.9 (-100.4,74.1)	14.1±18.3 (-74.8,82.7)
	<i>mean± SD (min, max)</i>			

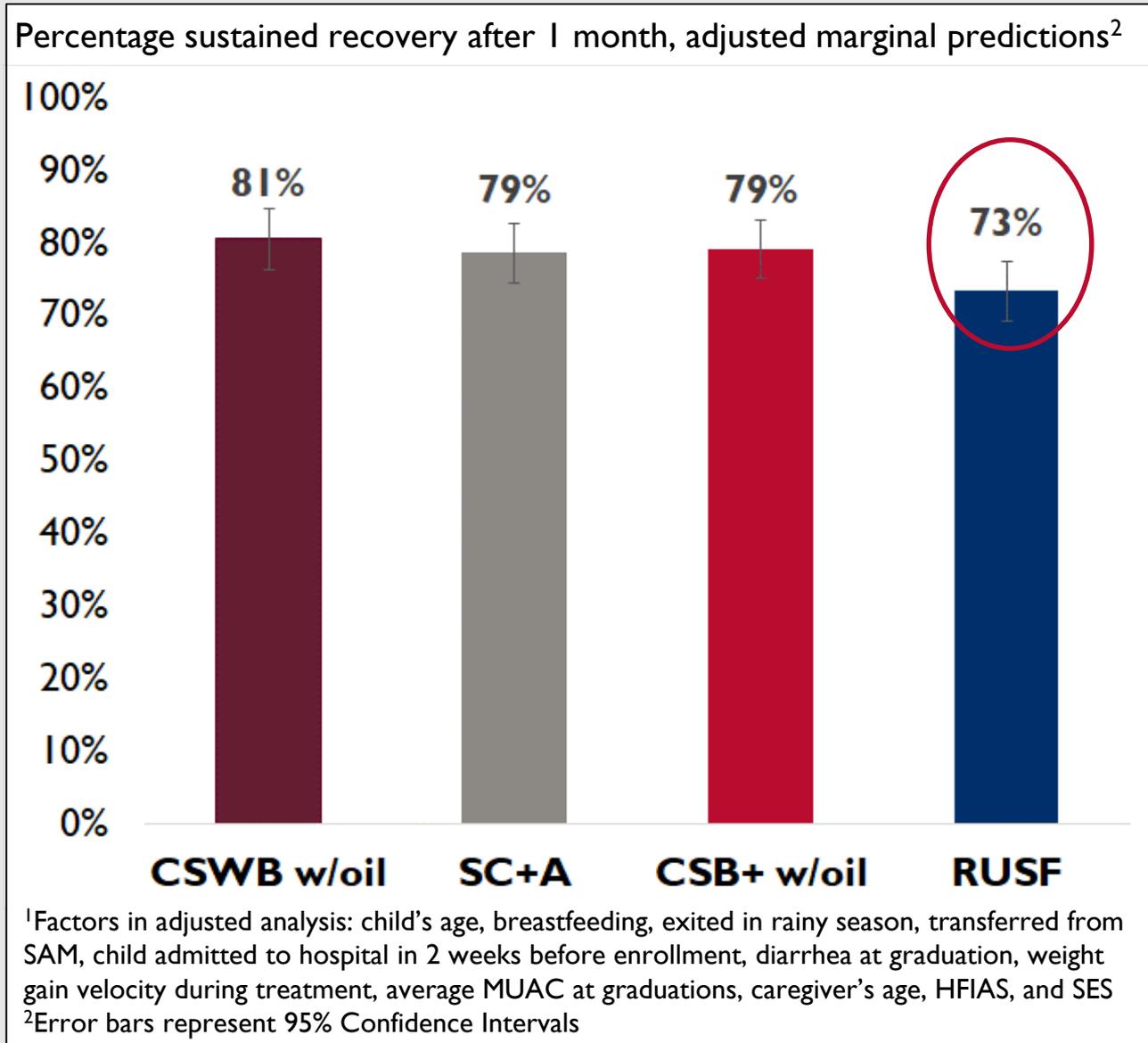


The story may be different when we look at rates of sustained recovery at 1-month after program exit



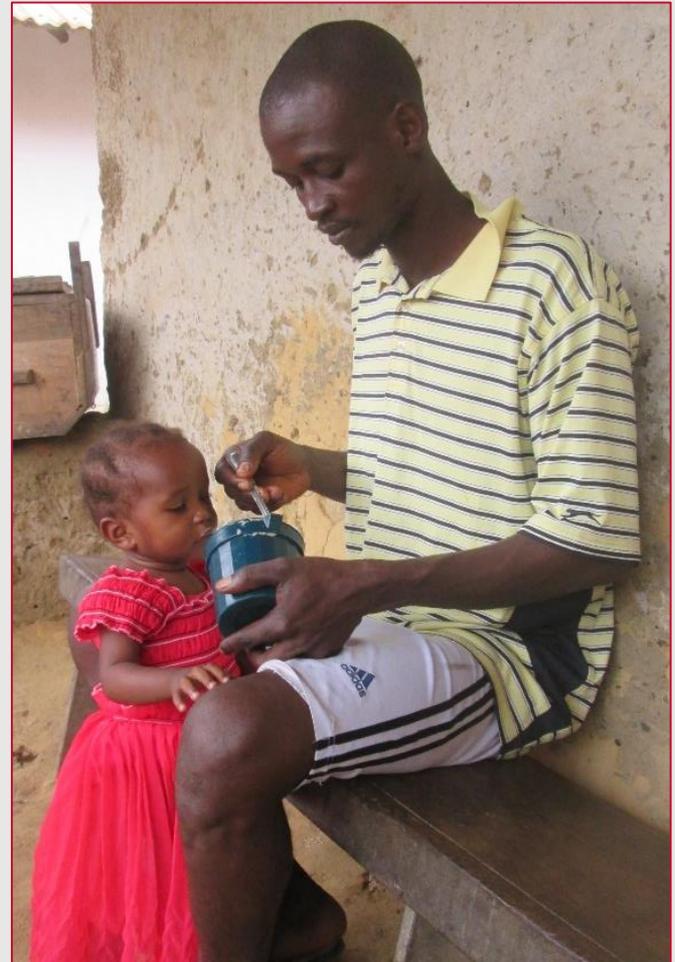
	CSWB w/oil	SC+A	CSB+ w/oil	RUSF	Total
	n (%)	n (%)	n (%)	n (%)	n (%)
Missed the 1-month Visit	31 (8.61%)	42 (10.12%)	25 (5.9%)	48 (10.06%)	146 (8.71%)

There was a difference in rates of sustained recovery at 1-month after program exit in both crude and adjusted models¹



Effectiveness Results Summary

- The Four Foods performed similarly across measures of effectiveness.
- In contrast, compared to fortified blended flours, the sustained recovery at 1-month post-treatment was lowest among children receiving RUSF.





Introduction and Background: The Four Foods MAM Treatment Study



Results of Main Study

- Comparative Effectiveness
- **Cost-effectiveness**
- Behavioral Factors Influencing Effectiveness



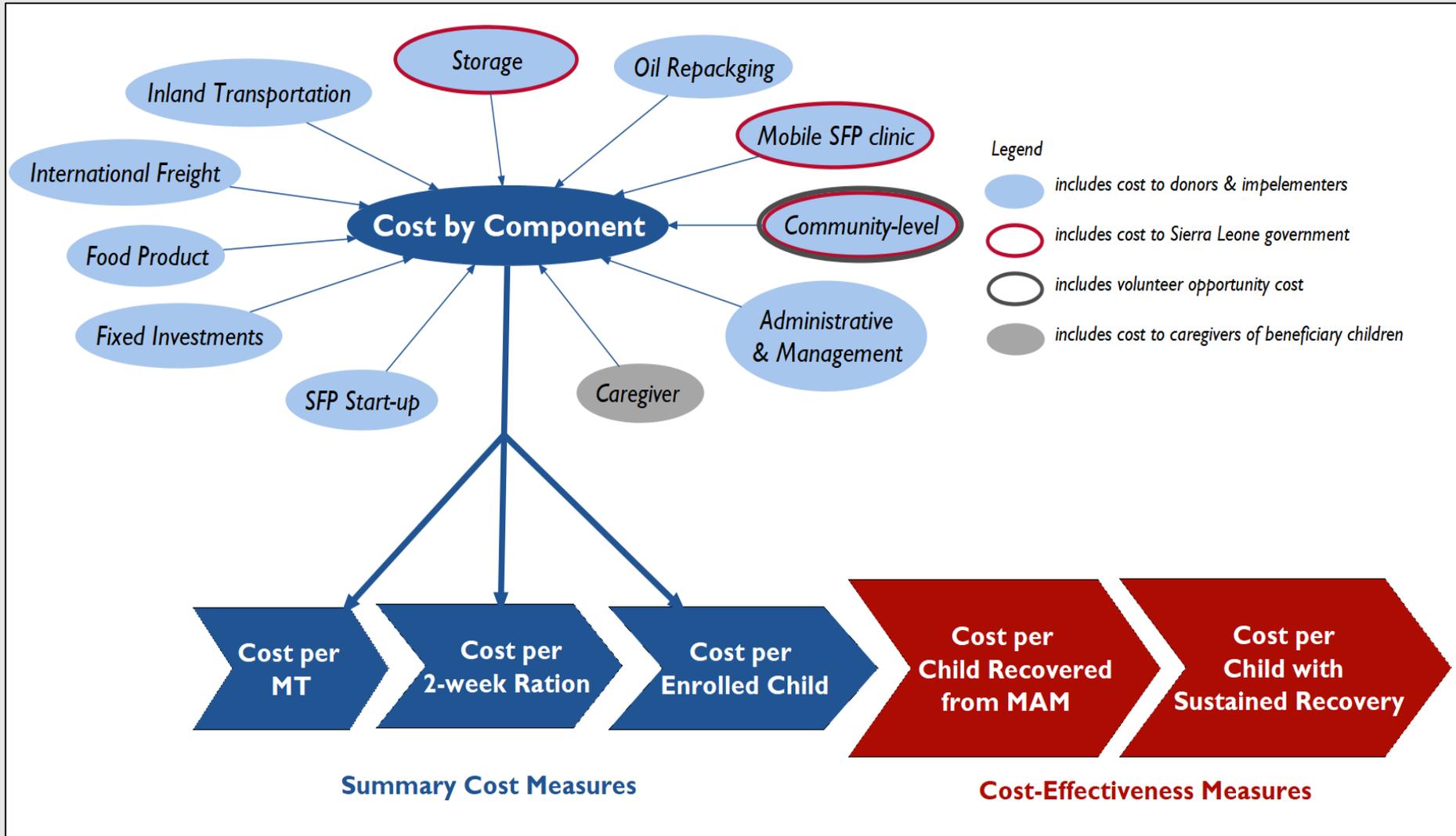
Three Sub-Studies

- Environmental Enteric Dysfunction
- Body Composition
- Neurocognition

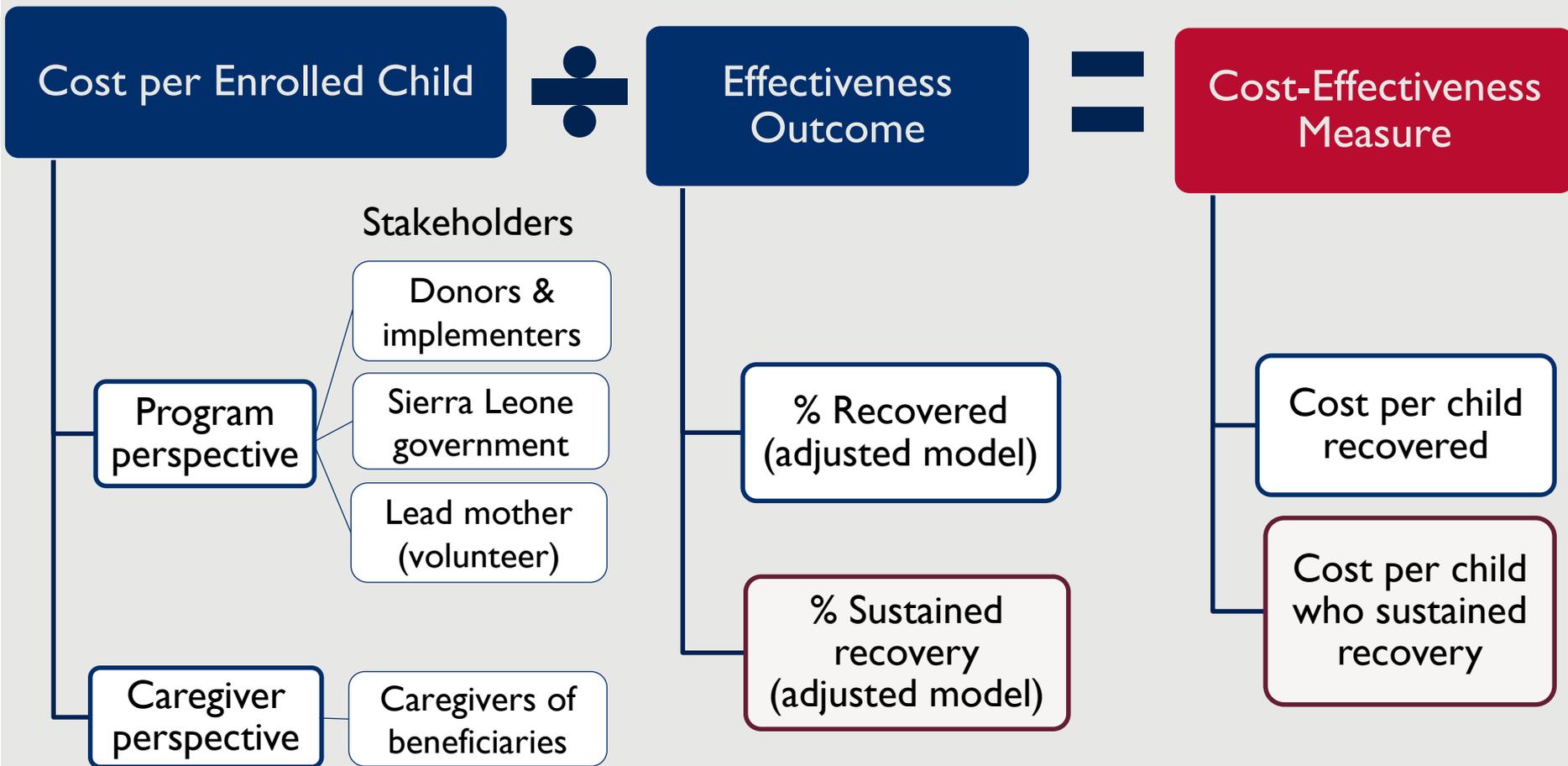


Implications for FFP Programming

Costing: We used an ingredients approach



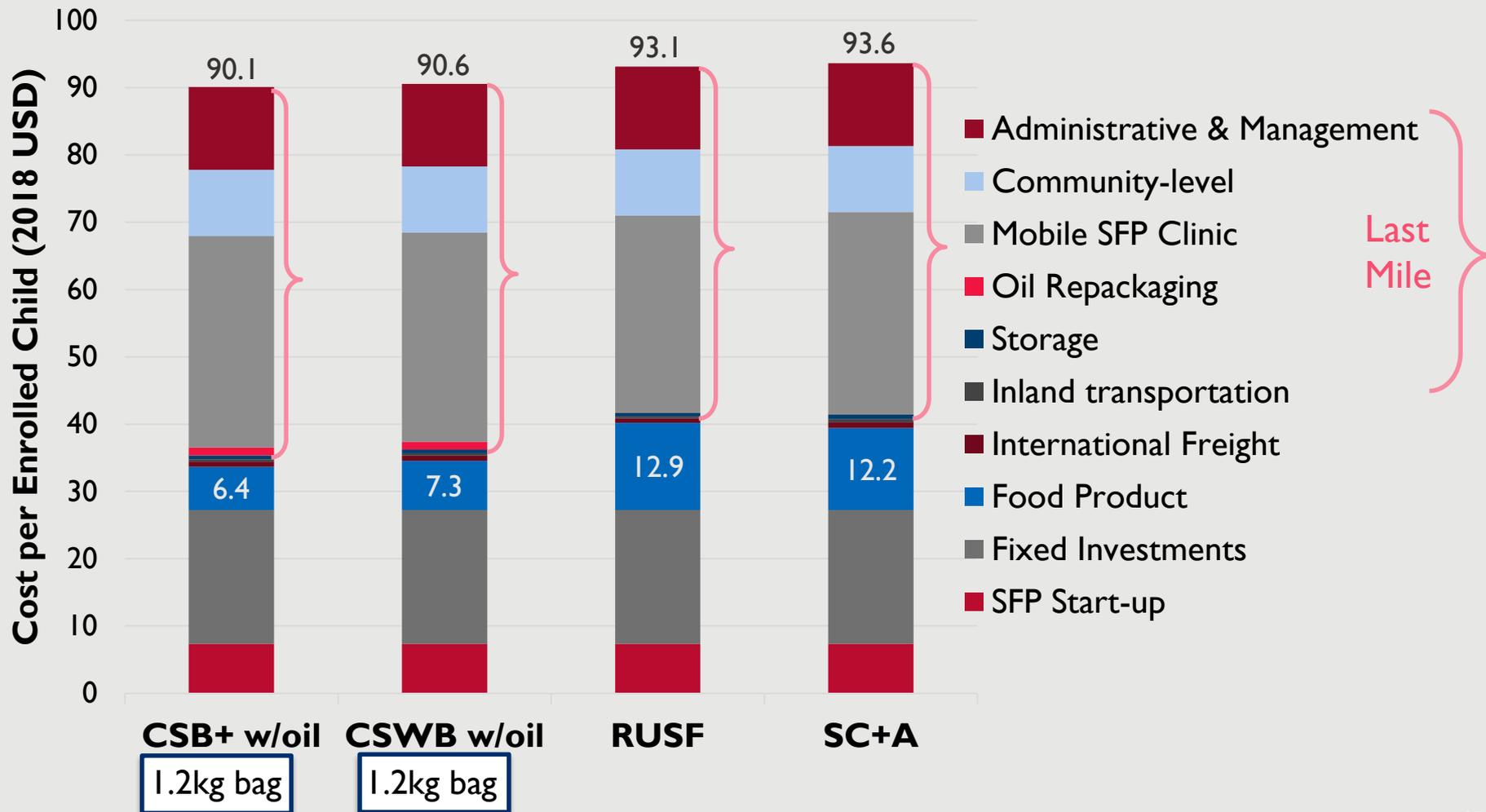
Cost-effectiveness: we examined cost per child recovered and cost per child who sustained recovery



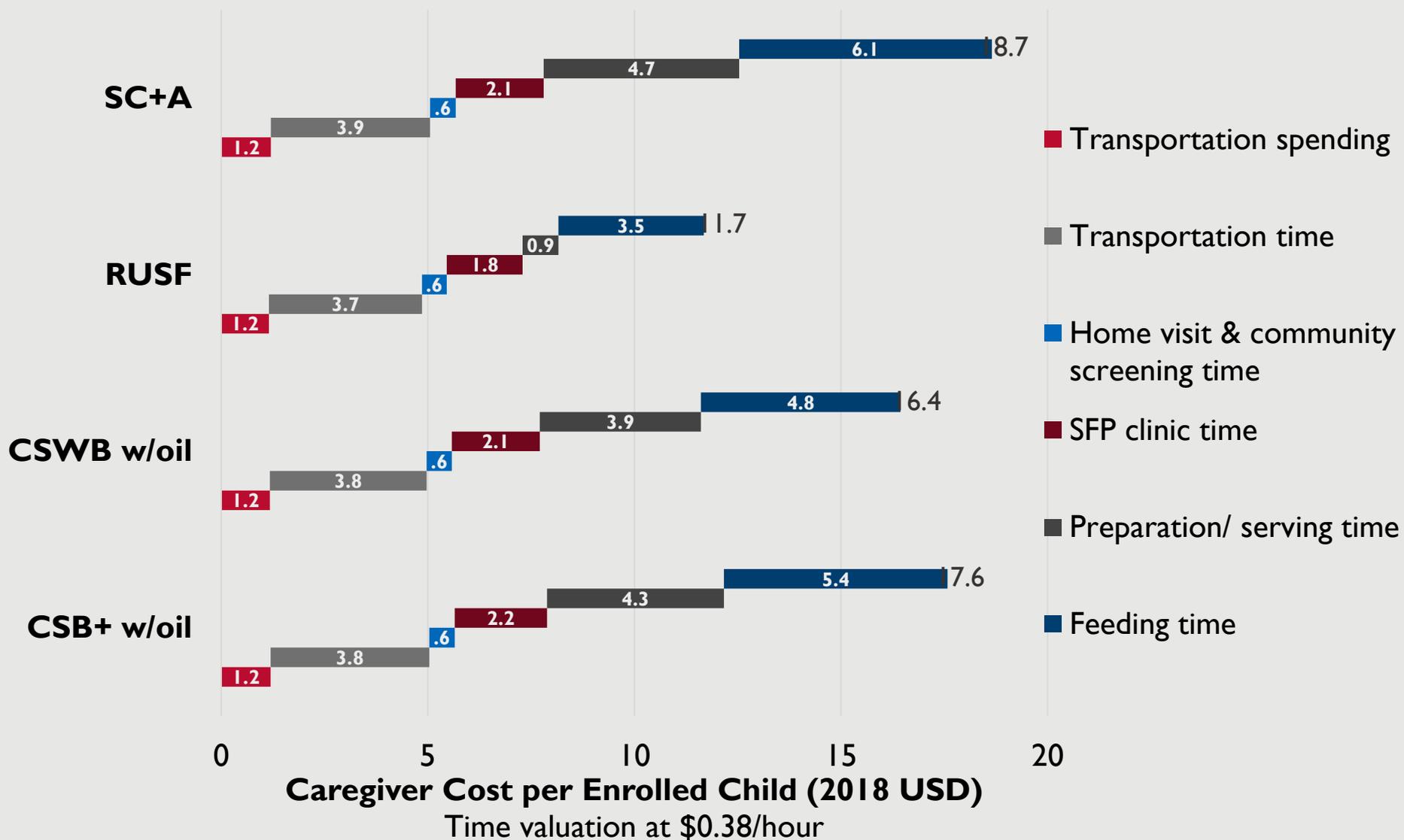
Program Perspective Only: Cost per enrolled child were similar across arms

FBFs experimental;
RUSF & FVO standard

All imported from USA

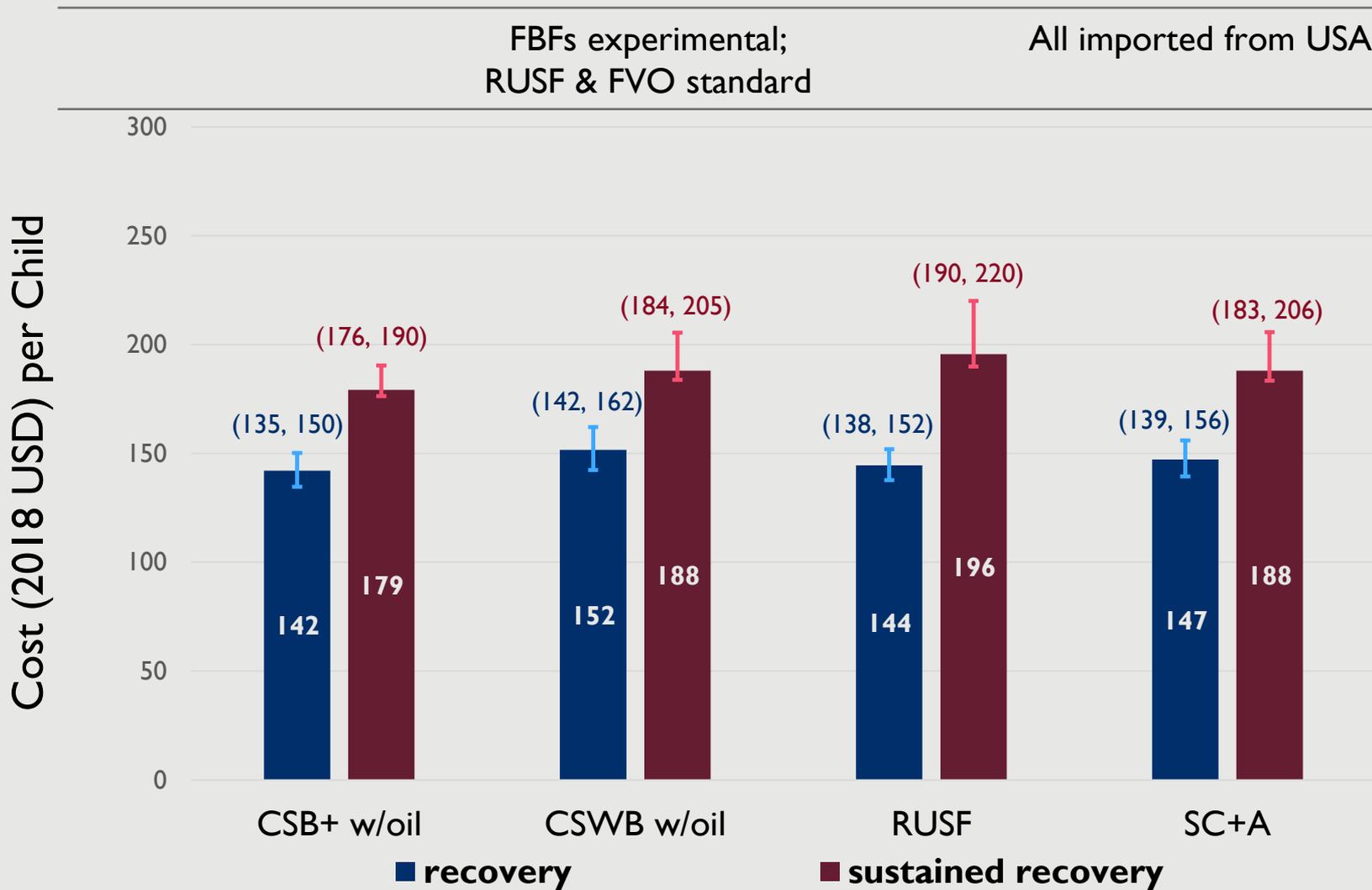


Caregiver Perspective Only: Cost per enrolled child was lowest in RUSF



Comparing cost per recovered child to cost per sustained recovery

No difference in cost-effectiveness by arm from program perspective



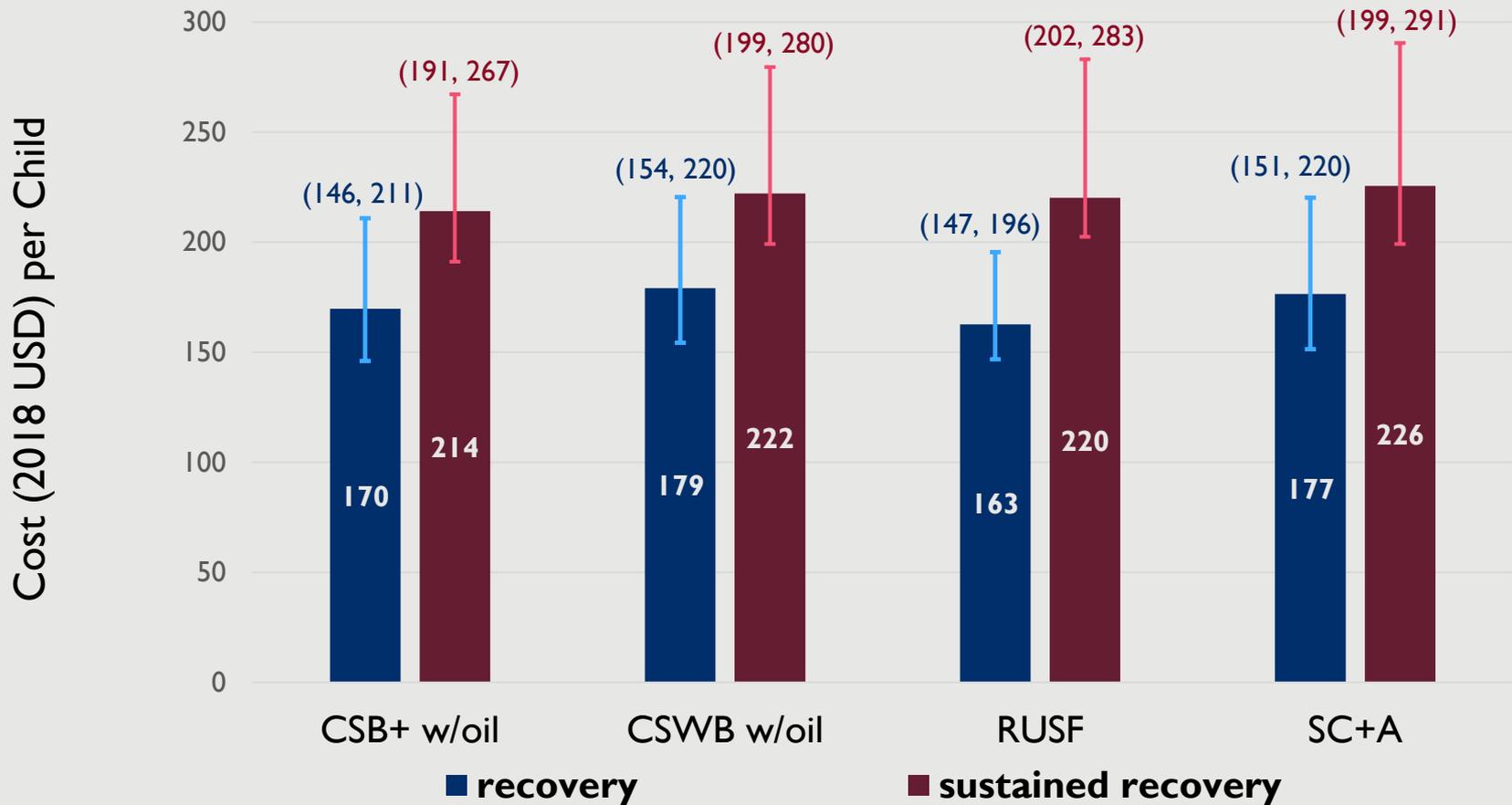
Error bars for both perspectives use 95% confidence intervals of recovery rate from the adjusted effectiveness model.
 Error bars used point estimates of sustained recovery from two adjusted models that treated missed visits at 1-month post intervention as all sustained recovery and as all relapsed.

Comparing cost per recovered child to cost per sustained recovery

No difference in cost-effectiveness by arm from combined perspective

FBFs experimental;
RUSF & FVO standard

All imported from USA



Error bars for program & caregiver perspective additionally incorporate uncertainty around time cost of caregivers (± 1 SD).

Cost-Effectiveness Results Summary

- From the program perspective, both cost per enrolled child and cost per child recovered from MAM were not significantly different among the four foods.
- From the caregiver perspective, cost per enrolled child was lowest for the RUSF.
- From the combined program & caregiver perspective: cost per child recovered from MAM was not significantly different among the four foods.
- Cost per child with sustained recovery was not significantly different among the foods but was more expensive than cost per child recovered.
- The largest drivers of caregiver cost differences among the foods were preparation/serving and feeding.
- The largest overall costs contributors were the mobile-SFP's operational costs.



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Implications for FFP Programming

There are hypotheses about the association between recovery and food specific factors like: following the recipe, sharing, consumption, and diet diversity

Food Sharing Practices in Households Receiving Supplemental Foods for the Treatment of Moderate Acute Malnutrition in Ethiopian Children

CRYSTAL D. KARAKOCHUK,^{1,2} TINA VAN DEN BRIEL,²
DEREK STEPHENS,³ and STANLEY ZLOTKIN^{1,4}

“CSB was reported to be shared among a significantly higher number of family members (1.9 ± 1.0) compared to RUSF (0.1 ± 0.4 ; $P < .001$).”

“A higher proportion of the RUSF ration was reported to have been consumed by the malnourished child compared to CSB.”

Effect of end-user preparation methods on vitamin content of fortified humanitarian food-aid commodities

J.P. Rowe, L.V. Ogden, O.A. Pike, F.M. Steele, M.L. Dunn *

“In CSB thin porridge, vitamins C and E showed cooking losses of 53% and 18%, respectively...”

“With the exception of vitamins C and E in CSB and vitamin A in SFB and VO, typical cooking had little effect on vitamin stability.”

Treatment of moderate acute malnutrition with ready-to-use supplementary food results in higher overall recovery rates compared with a corn-soya blend in children in southern Ethiopia: an operations research trial¹⁻⁵

Crystal Karakochuk, Tina van den Briel, Derek Stephens, and Stanley Zlotkin

“The daily rations were equivalent to 300g CSB and 32g vegetable oil (1413 kcal, 47g protein) or 92g RUSF (500 kcal, 13g protein).”

“Note that the quantity of the CSB ration is purposely higher because of expected household food sharing of the CSB ration.”

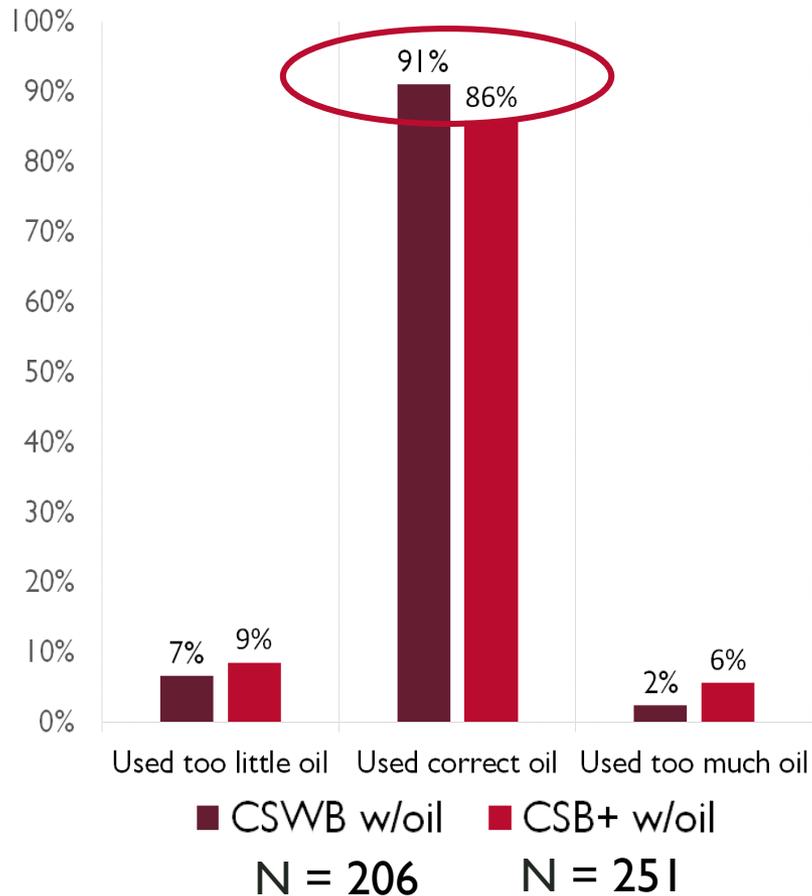
Amylase increases energy and nutrient density of Super Cereal Plus porridge as prepared and accepted by Rwandan caregivers

Britt Broersen¹ | Sisay Sinamo² | Jules Nsabimana³ | Tanimoune Mahamadou⁴ | Edgar Gatete³ | Shane Prigge¹ | Nguyen Van Hoan¹ | Saskia de Pee^{1,5,6}

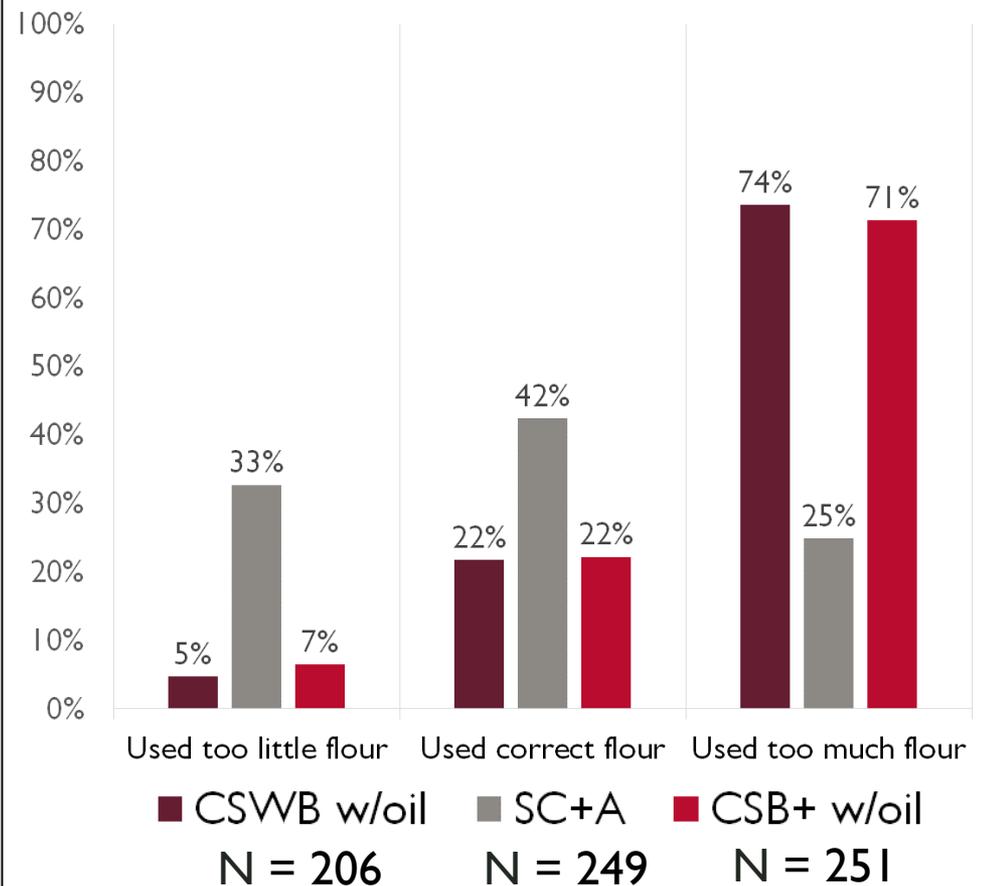
“...it is essential that SC+A flour is mixed with water of ambient temperature...”

Caregivers reported adding the correct amount of oil, but flour was varied

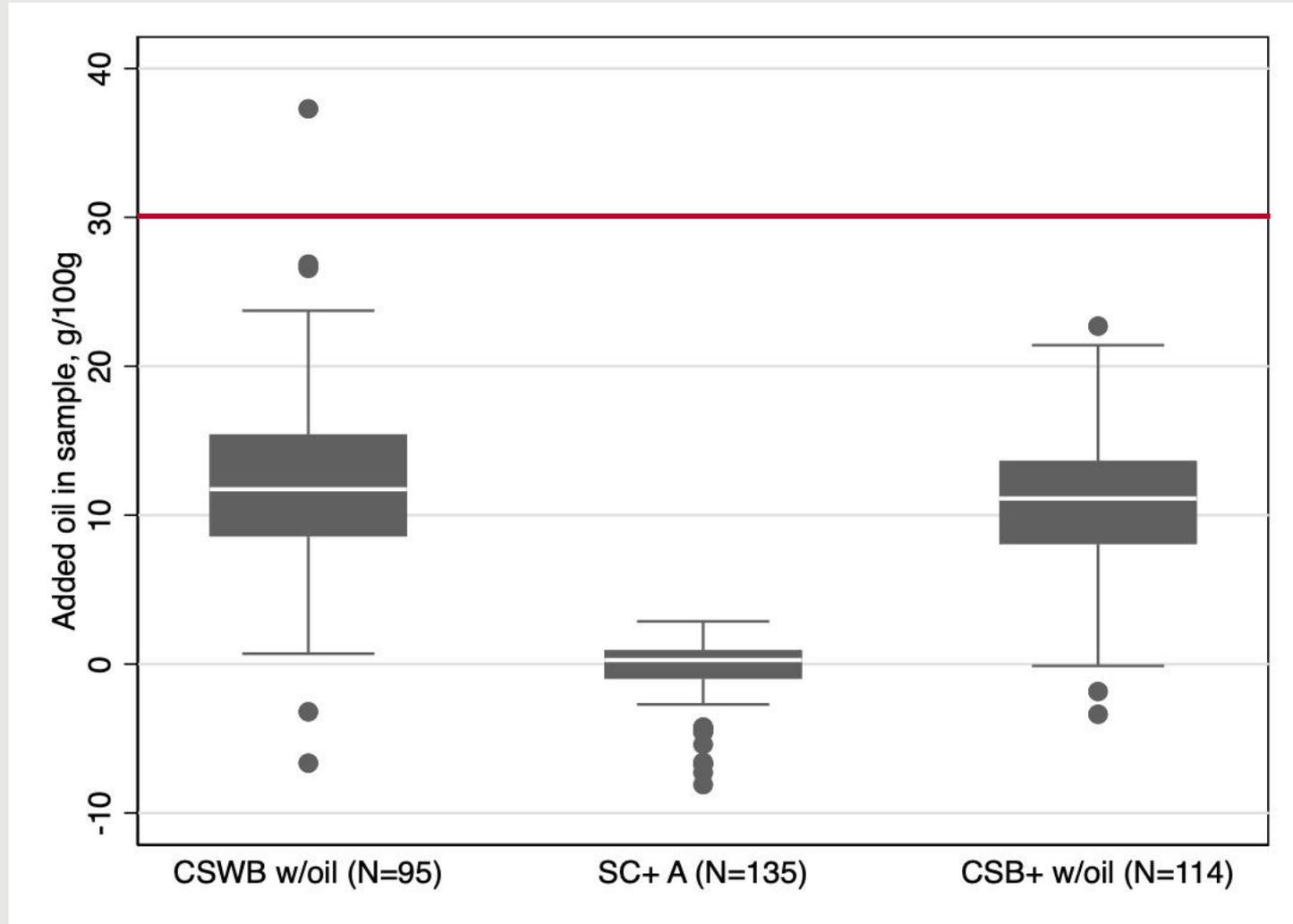
Percent of caregivers reporting quantity of **oil** used at last preparation occasion



Percent of caregivers reporting quantity of **flour** used at last preparation occasion

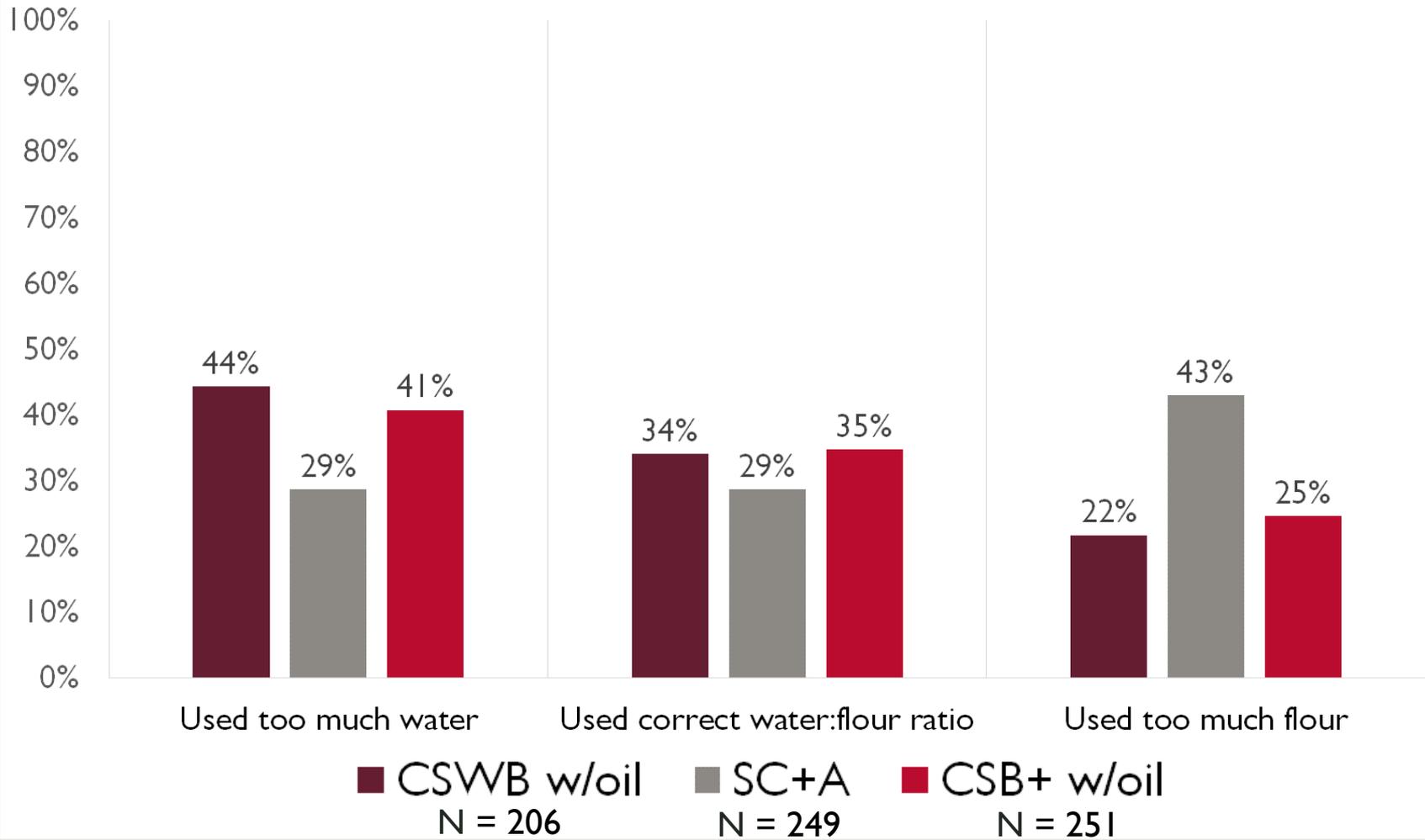


The ratio of oil/flour was generally below recommendations



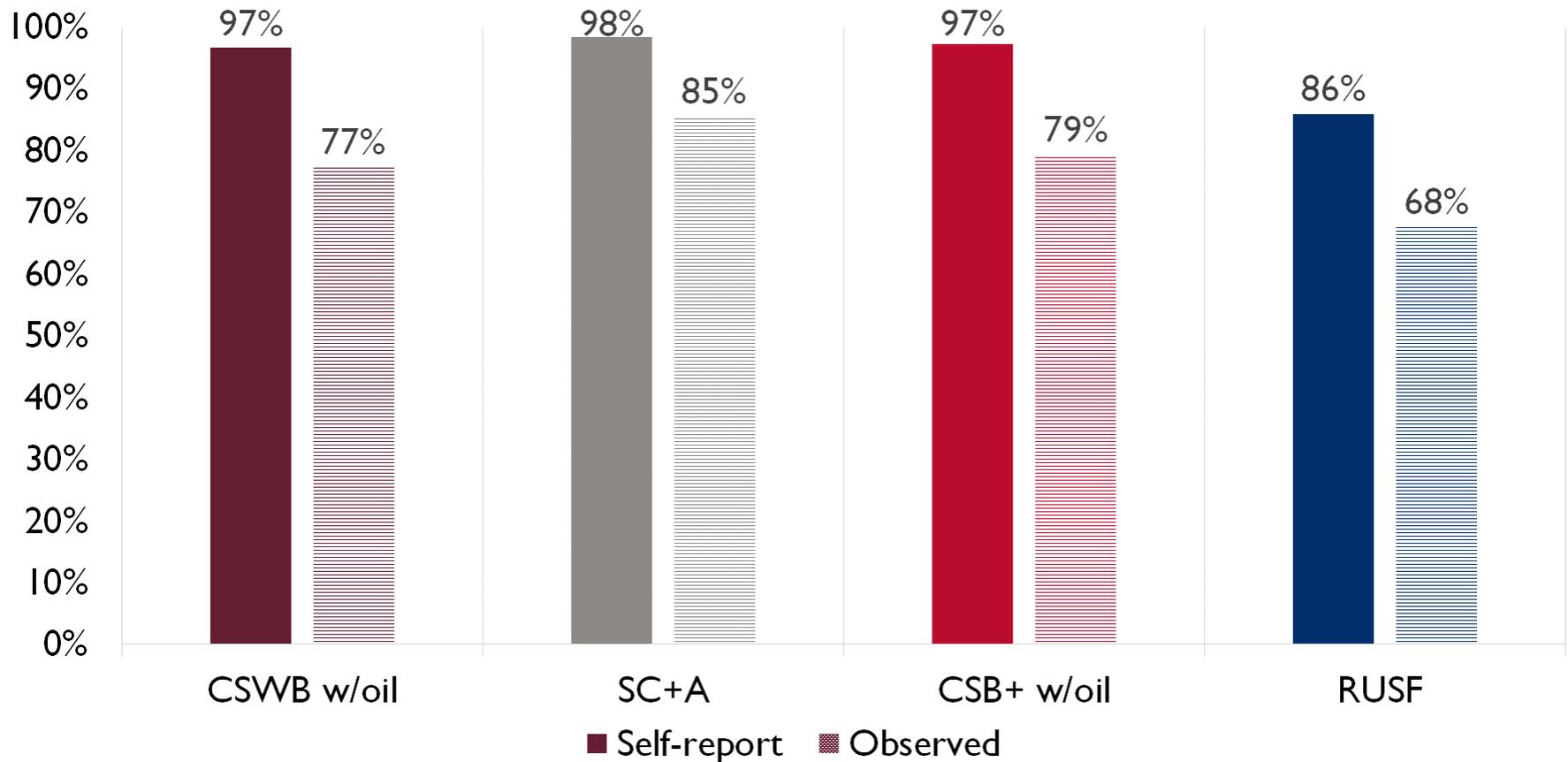
Caregivers reported using different ratios of water to flour

Ratio of water/flour by tercile: percent of caregivers by food separately reporting water used and flour used at last preparation occasion



Few caregivers mixed the study food with other ingredients

Percent of caregivers self-reporting or percent of households observed using only the ingredients recommended

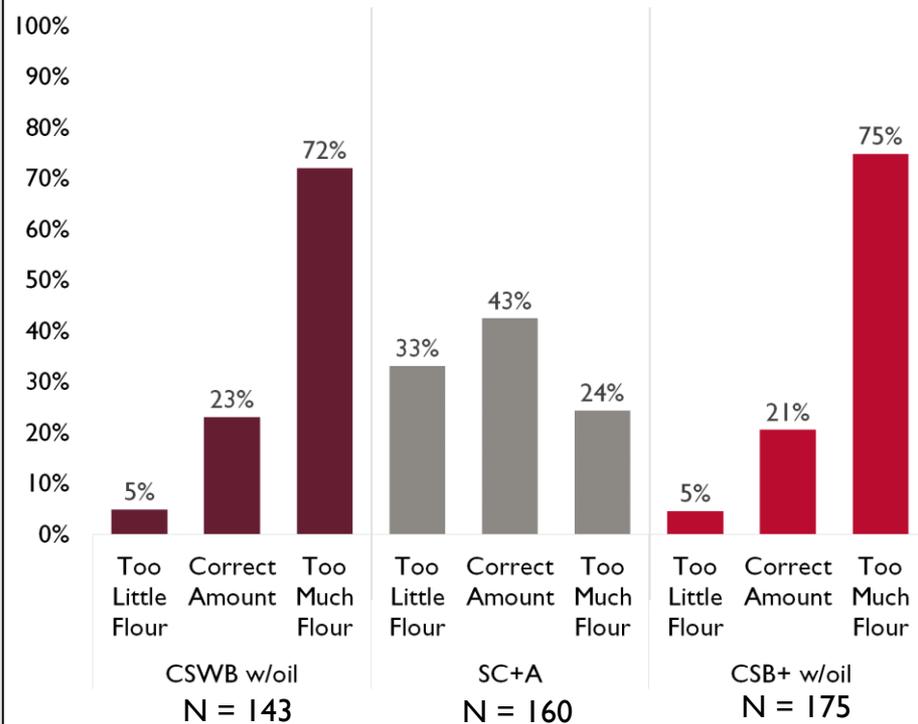


Observed: CSWB: N=70, SC+A: N=82, CSB+: N=91, RUSF: N=80

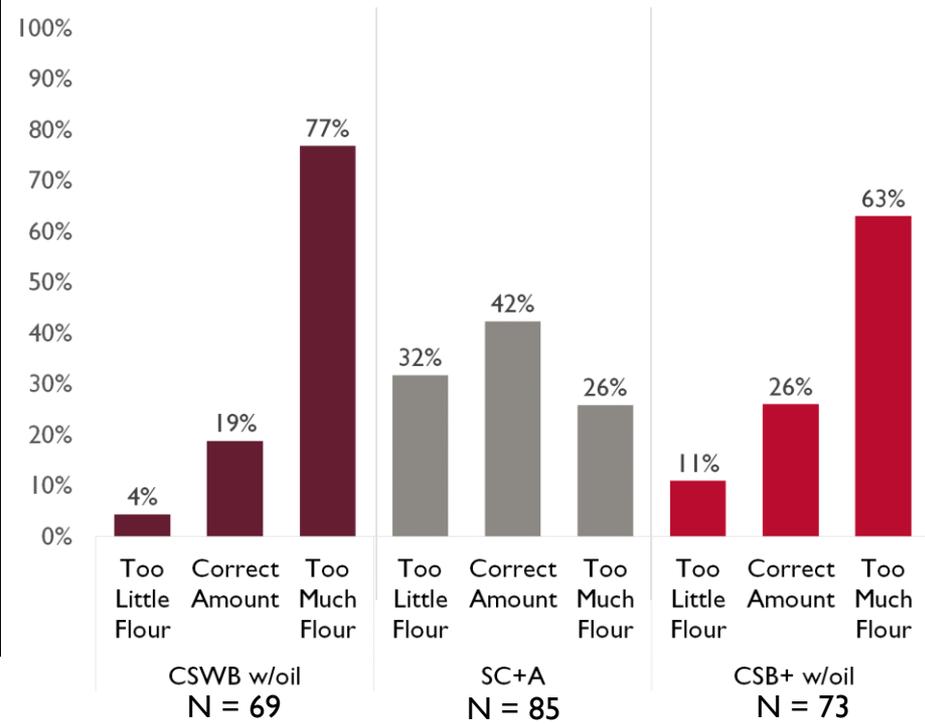
Self-report: CSWB: N=205, SC+A: N=241, CSB+: N=241, RUSF: N=212

It may not matter: Adherence to protocol is not associated with recovery

Percent of children who **recovered** by arm in each tercile of quantity of flour used

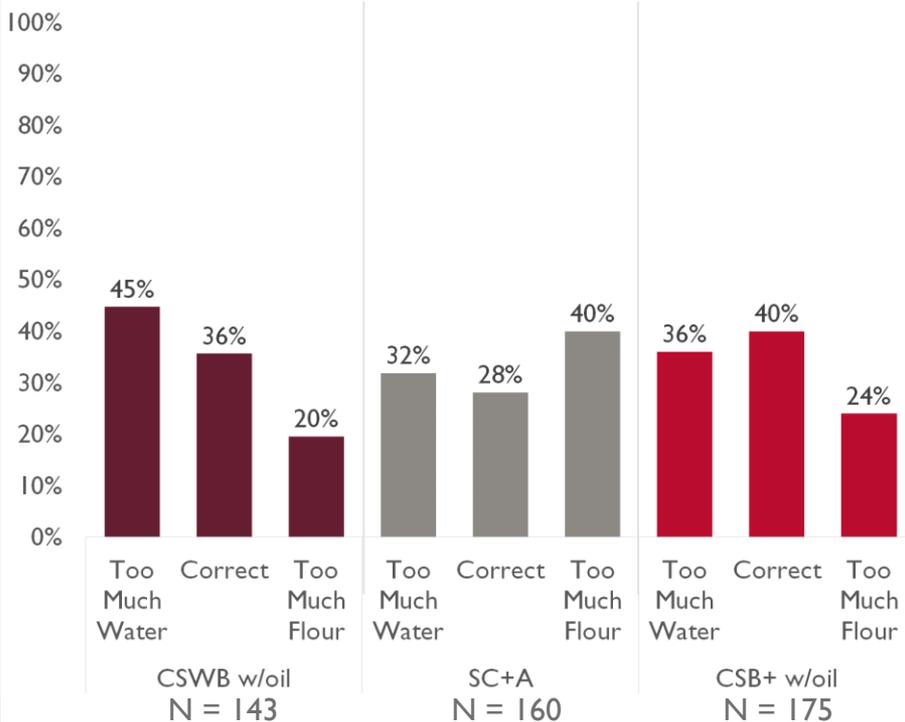


Percent of children who **did not recover** by arm in each tercile of quantity of flour used

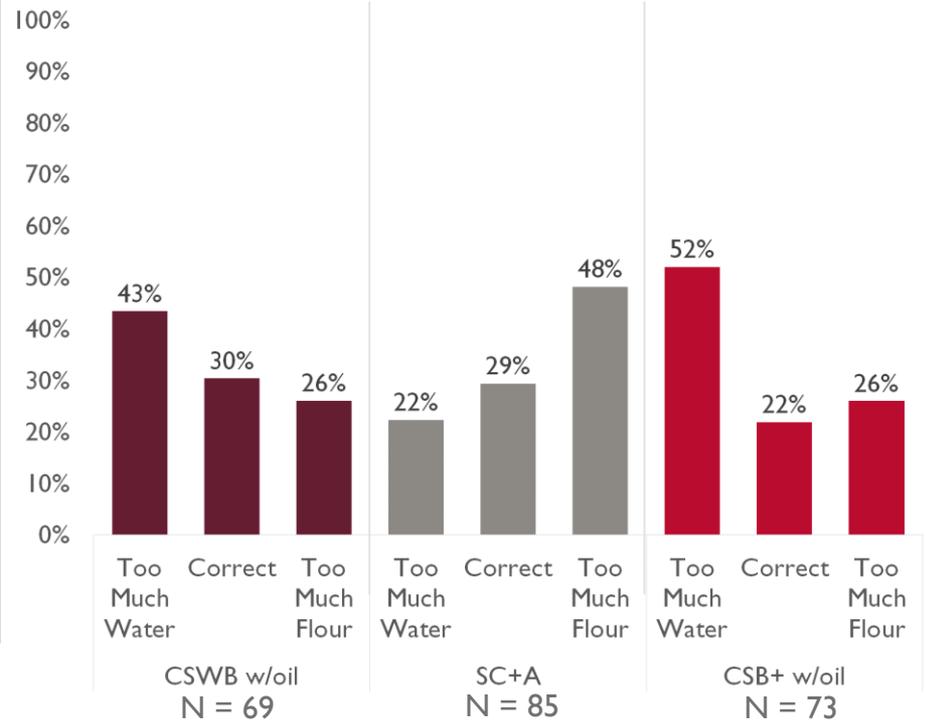


It may not matter: Adherence to protocol is not associated with recovery

Percent of children who **recovered** by arm in each tercile of quantity of water:flour ratio used

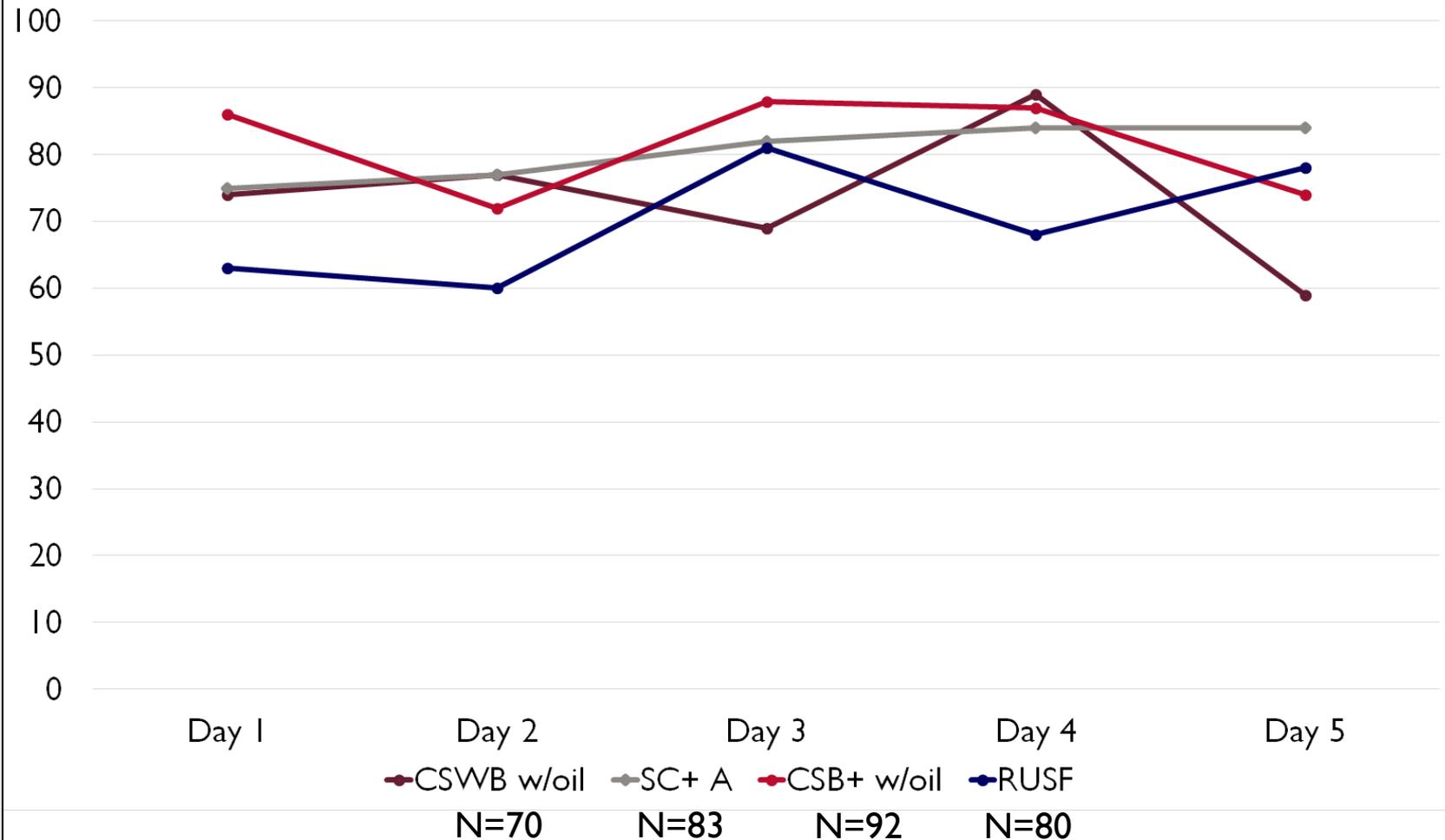


Percent of children who **did not recover** by arm in each tercile of quantity of water:flour ratio used



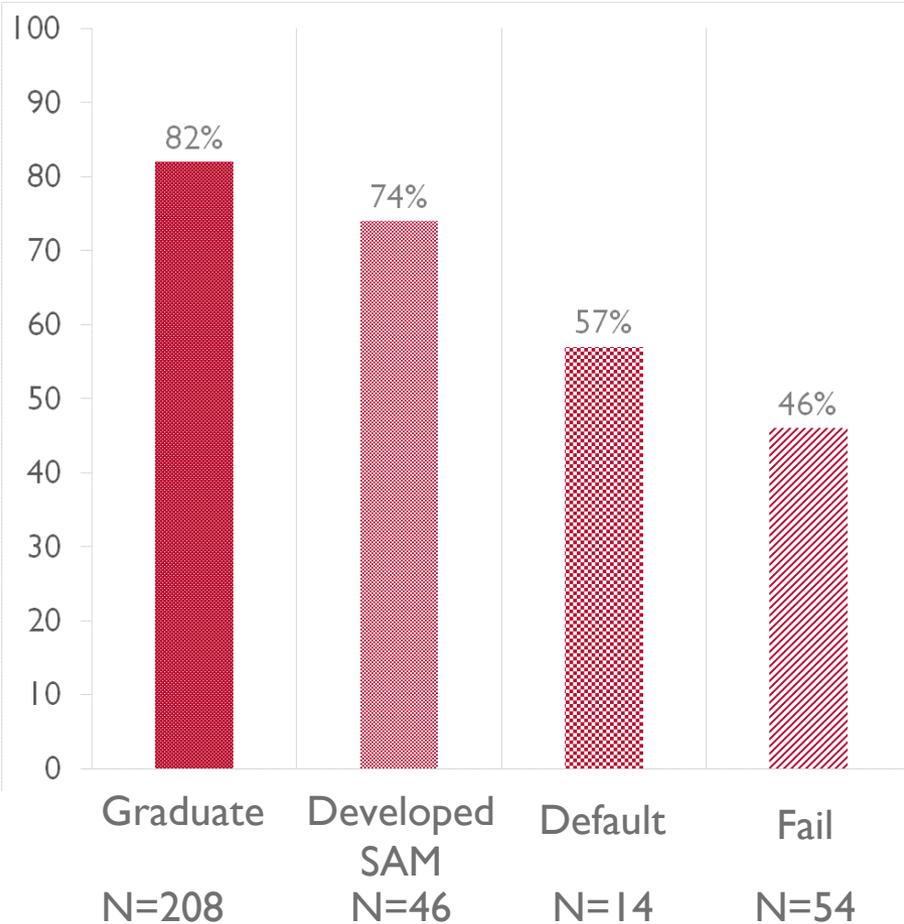
Observed consumption of the food was high among all households

Percent of households where the target child was observed eating the study food at least once on the day of the recorded observation

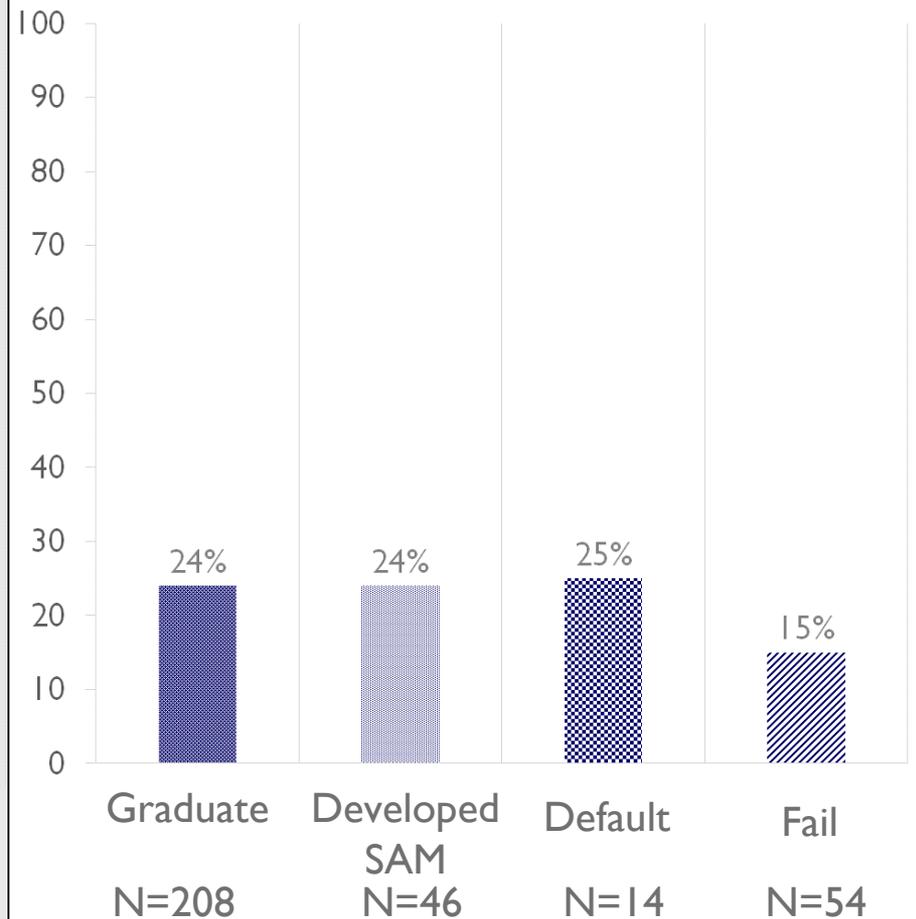


Observed consumption of the food differed by outcome

Percent of households in which beneficiary was observed **consuming** the food at least one day in five, by outcome

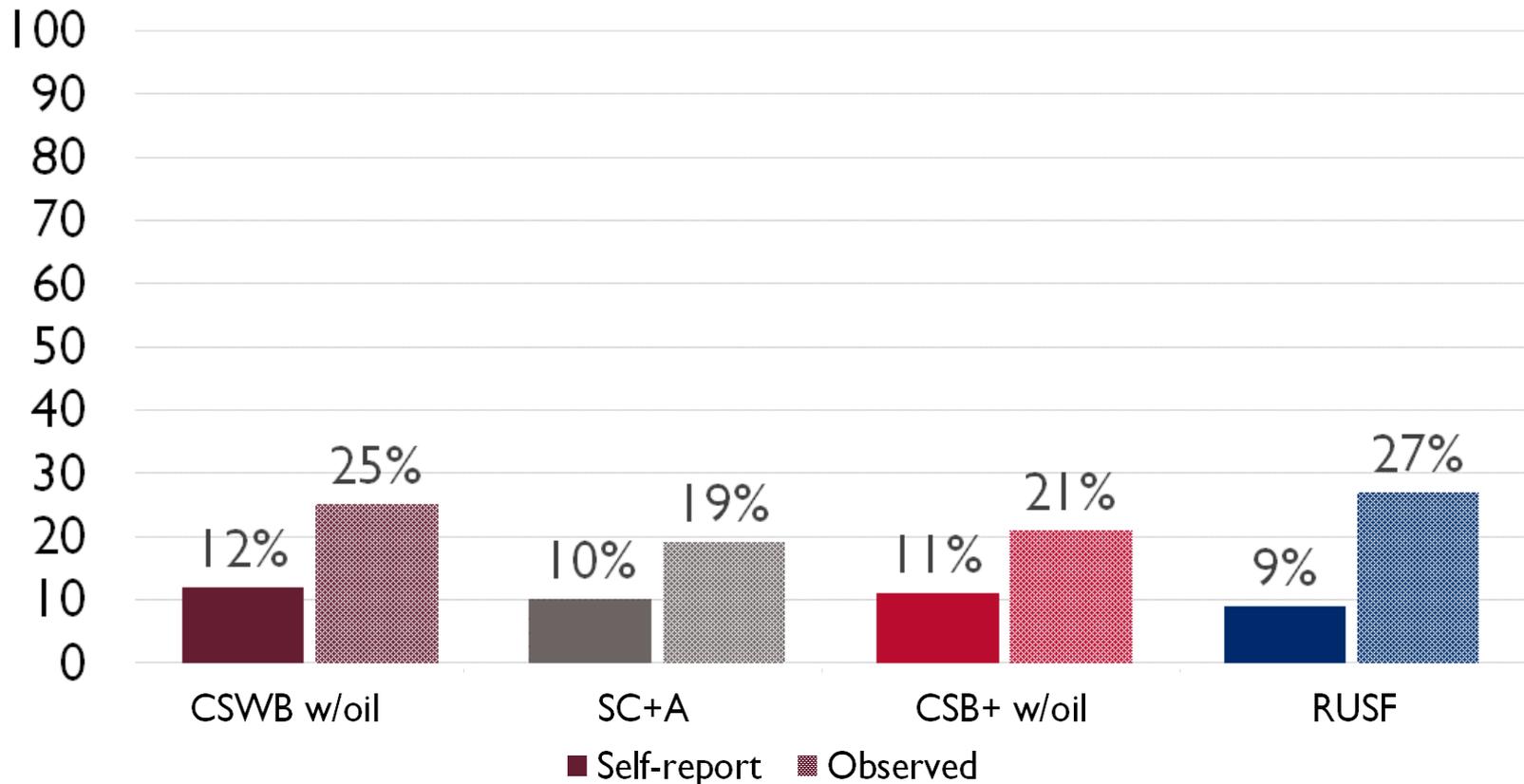


Percent of households in which food was observed **being shared** with someone other than child at least one day in five, by outcome



Sharing occurred for all foods, and occurred more often than was reported

Percent of caregivers reporting sharing food with any person other than beneficiary child compared to percent of households where any occasion of sharing with other person was observed

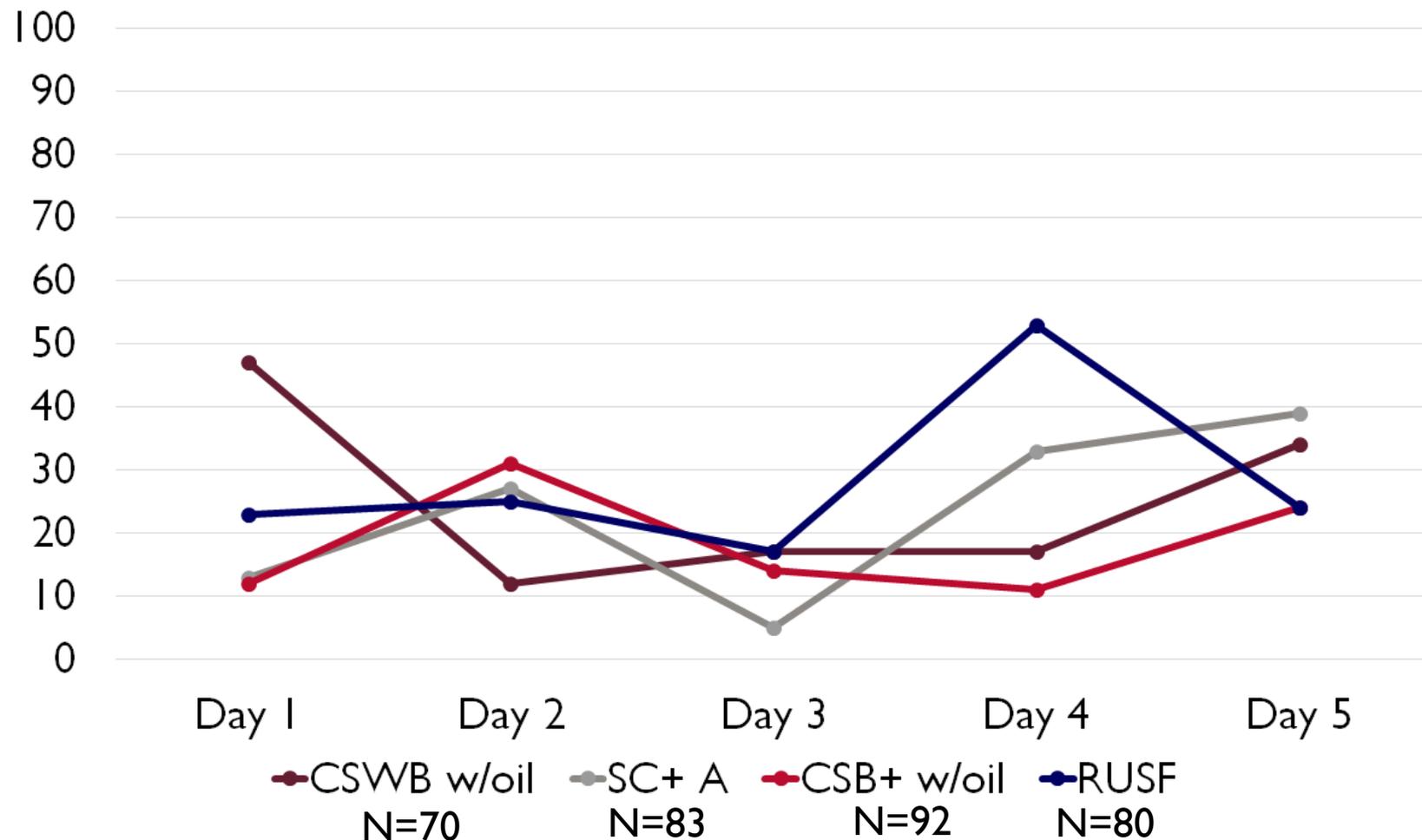


Observed: CSWB: N=55, SC+A: N=70, CSB+: N=77, RUSF: N=59

Self-report: CSWB: N=212, SC+A: N=248, CSB+: N=251, RUSF: N=248

Observed sharing did not change by day

Percent of households where the study food was observed being shared with someone other than the beneficiary child at least once on the day of observation



The top reported reasons for sharing were related to health*

Reported Reason	N (%)
It is good for health	330 (34)
It treats illness	291 (30)
Other children need or want	263 (27)
Other adults need or want	97 (10)
Other reason	53 (6)
Caregiver is breastfeeding the child	47 (5)
Not enough other food in the house	25 (3)
Receive more than child needs	18 (2)
Morally obligated to share	20 (2)
Not enough money to buy food	11 (1)
Total N	971

* Multiple responses were permitted



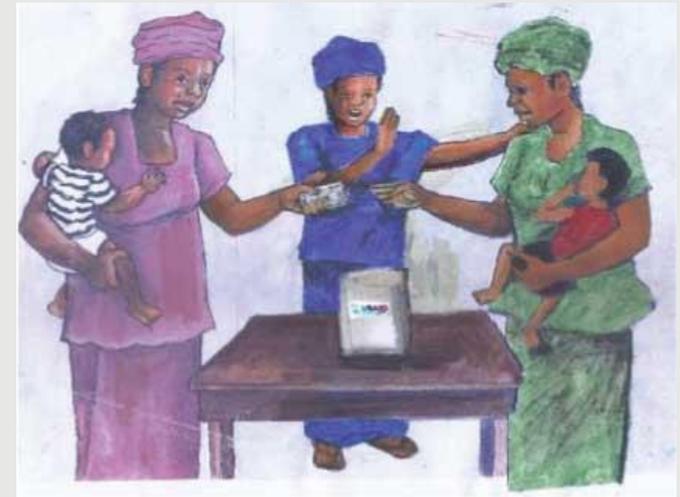
Health and acceptability as reasons for sharing and selling were elaborated on in focus group discussions



“If a colleague mothers’ child is thin in structure and not actually the beneficiary child, if the mother request by saying please, let me have some of the blended to give to my child I will measure some of the blended and give it to her for her to cook it for her child.”

“Even my child now, when she sees the food with a colleague mothers’ child, she will cry for the food and if I see where they are selling the food, I will buy it.”

“I have another kid that does ask for the pot and I give it to her. She will eat the pap [porridge] in it.”



Dietary diversity was similar across the arms but highest in RUSF

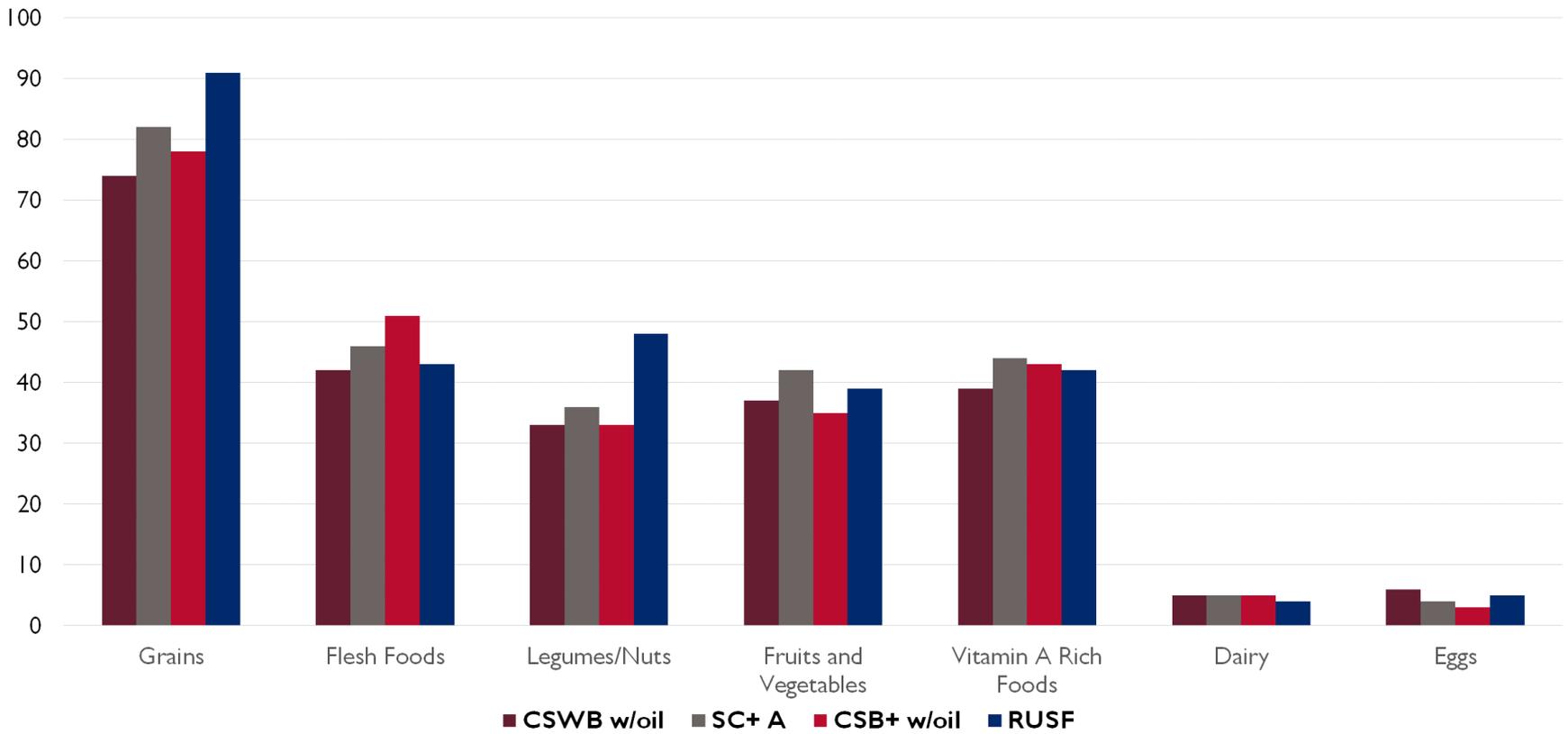
Mean diet diversity score (0-7) ^{1 2}			
CSWB (n=187)	SC+A (n=220)	CSB+ (n=226)	RUSF (n=226)
2.37 ± 1.66	2.6 ± 1.75	2.48 ± 1.78	2.71 ± 1.66

¹ Food groups consumed in the 24 hours prior to the interview, excluding study foods
² Diet diversity calculated using Infant and Young Child Minimum Diet Diversity (IYCMDD)



Differences in Dietary Diversity were centered around Grains and Legumes/Nuts

Percent of caregivers reporting the beneficiary ate a food in each food group in the previous 24-hour period^{1 2}



¹ Food groups consumed in the 24 hours prior to the interview, excluding study foods

² Diet diversity calculated using Infant and Young Child Minimum Diet Diversity (IYCMDD)

Results Summary

- Neither sharing, displacement, nor following recommendations were associated with differences in recovery.
- Differences in consumption by outcome were observed; children who recovered were observed to eat the food in more households than among children who did not recover.
- Sharing was prevalent in all arms but was highest among recipients of RUSF and lowest for SC+A.
- Adherence to cooking instructions was high for flour and oil usage across FBFs.
- In SC+A caregivers generally used less water or more flour than recommended.



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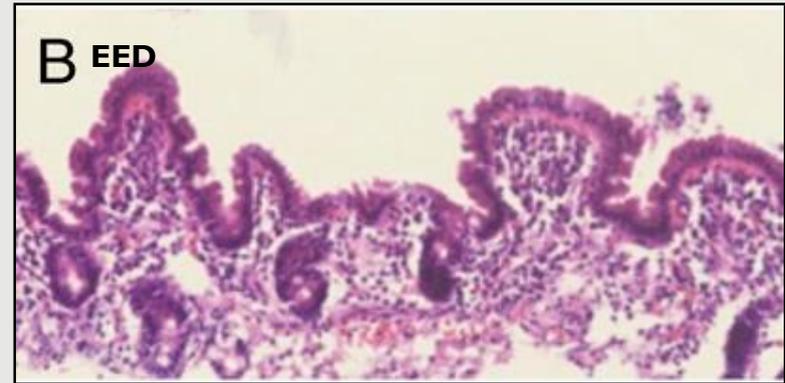
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Implications for FFP Programming

The role of gut/ intestinal health in MAM treatment



- A complete complement of nutrients are needed to build a strong, normal functioning gut. The main functions of the gut are absorption of nutrients to maintain health and create a barrier to protect the body from microbes.
- Environment Enteric Dysfunction (EED): shortened fingers (absorptive surface), permeability, and inflammation/ irritation of the small intestine.
- The presence of EED associated with poor growth (length³ and weight⁴).

¹Owino et al. 2016. "Environmental Enteric Dysfunction and Growth Failure/ Stunting in Global Child Health." *Pediatrics*.

²Gehrig et al. 2019. "Effects of microbiota-directed foods in gnotobiotic animals and undernourished children." *Science*.

³Harper et al. 2018. "Environmental enteric dysfunction pathways and child stunting: A systematic review." *PLOS Negl Trop Dis*.

⁴Campbell et al. 2018. "Environmental enteric dysfunction and systemic inflammation predict reduced weight but not length gain in rural Bangladeshi children." *Br J Nutr*.

Research questions for EED sub-study

1. Does environmental enteric dysfunction (EED) modify the effect of supplementary feeding on recovery ($\text{MUAC} \geq 12.5\text{cm}$) from MAM?
2. Does any one of the four foods achieve recovery better than another in the presence of EED?
3. Is there an improvement in EED over four weeks of treatment? Does any one of the four foods perform differently than another at improving EED?

EED biomarkers used in this sub-study

- Dual sugar absorption tests (Lactulose: Mannitol, L: M) test
 - Sugars that the body cannot normally metabolize are given orally.
 - These sugars are detected in urine.
 - The amount of %L detected is a quantitative measure of gut leakiness (permeability).
 - Elevated permeability: $\%L \geq 0.2^5$.
- Fecal host mRNA transcripts (detection of molecules made by the human in the gut)
 - Stool collected.
 - These molecules measure inflammation, permeability, and anti-microbial properties (ability to fight microbes).
 - Fifteen fecal host mRNA transcripts were explored in this study.

⁵ Yu et al. 2015. "Environmental Enteric Dysfunction Includes a Broad Spectrum of Inflammatory Responses and Epithelial Repair Processes." *Cell Mol Gastroenterol Hepatol*.

Biological samples collected at enrollment and after 4 weeks of supplementation



Day 1:
Consent



Day 2:
L: M dose



Day 30:

Day 2:
Urine collected (4 hours)
Stool* collected at any point

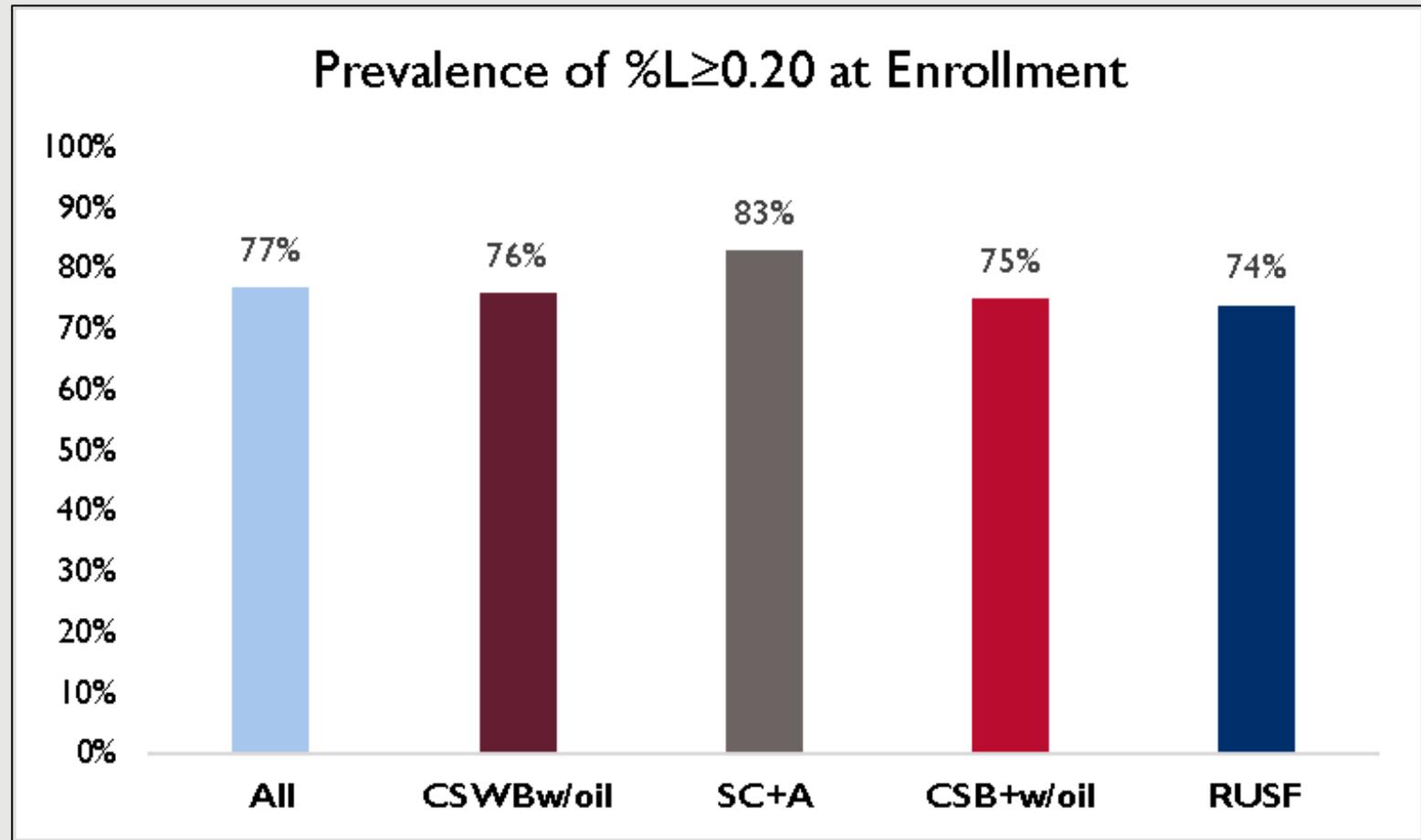
Day 30:
Stool collected

*Stool samples used for fecal host mRNAs

Research Question I

Does environmental enteric dysfunction (EED) modify the effect of supplementary feeding on recovery ($MUAC \geq 12.5\text{cm}$) from MAM?

High prevalence of permeability at enrollment using %L



n=484

(CSWB w/oil=74, SC+A= 142,
CSB+ w/ oil=122, RUSF=146)

P-value=0.407

Factor analysis used to create fecal host mRNA transcript-based scores

Gut Inflammation Score

AQP9
CD53
IFI30
LYZ
PIK3API
SI00A8
SELL

Gut Structure Score

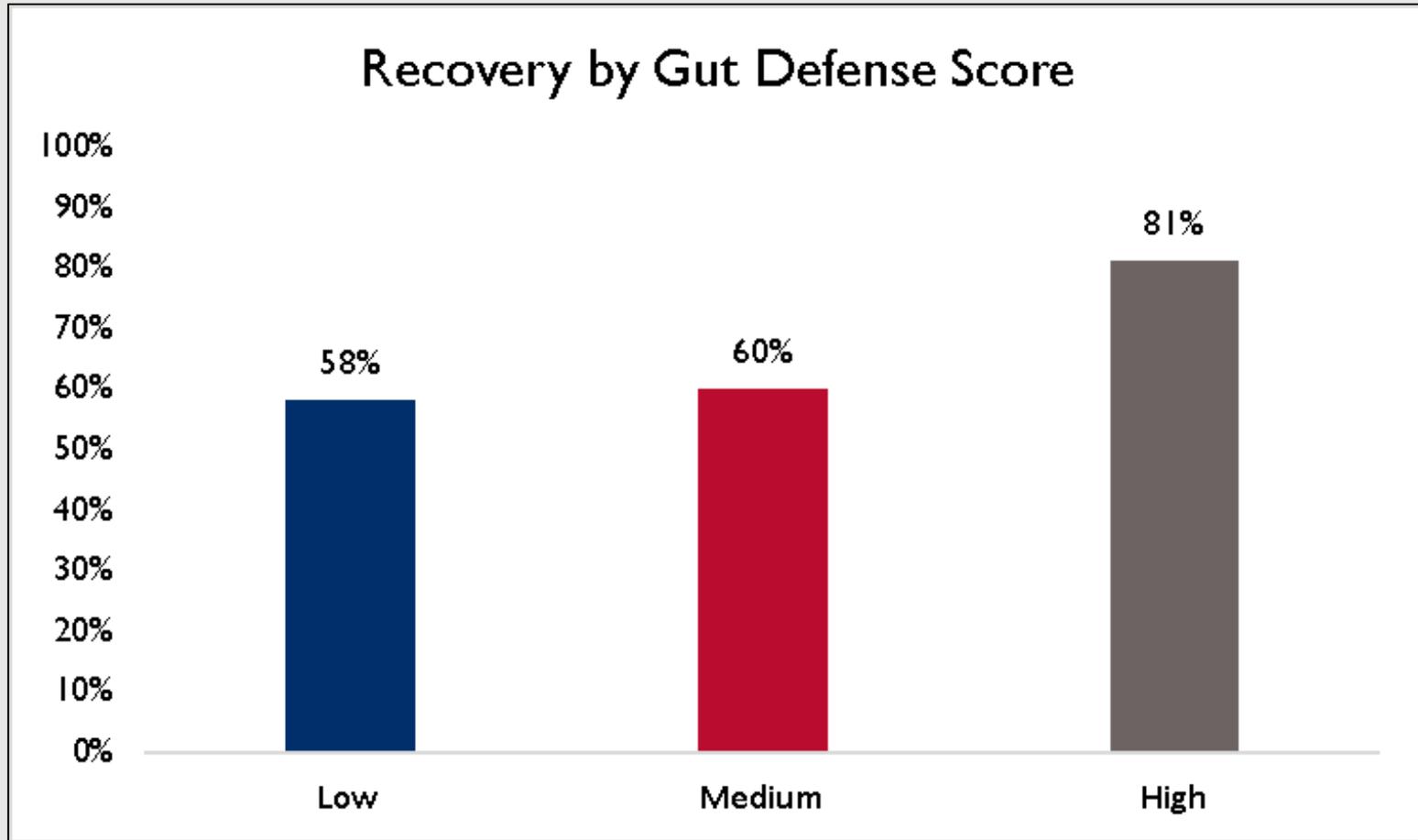
BIRC3
CDXI
DECRI
HLA-DRA
MUC12

Gut Defense Score

DEFA6
REG3A
REGIA

*Created terciles for each score by dividing into three equal groups.

Gut Defense Score at enrollment predicts recovery from MAM (MUAC \geq 12.5cm)



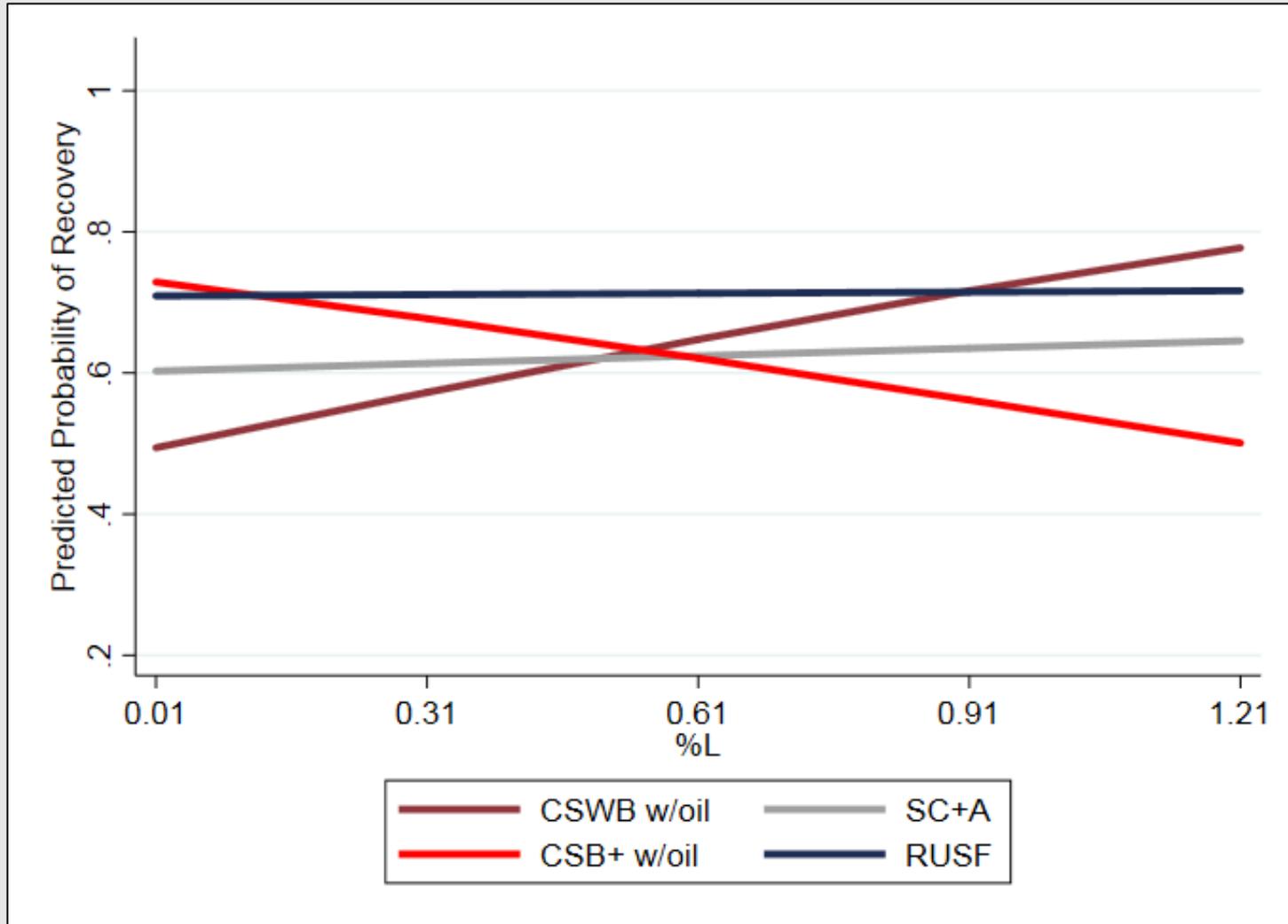
n=389

P-value <0.001

Research Question 2

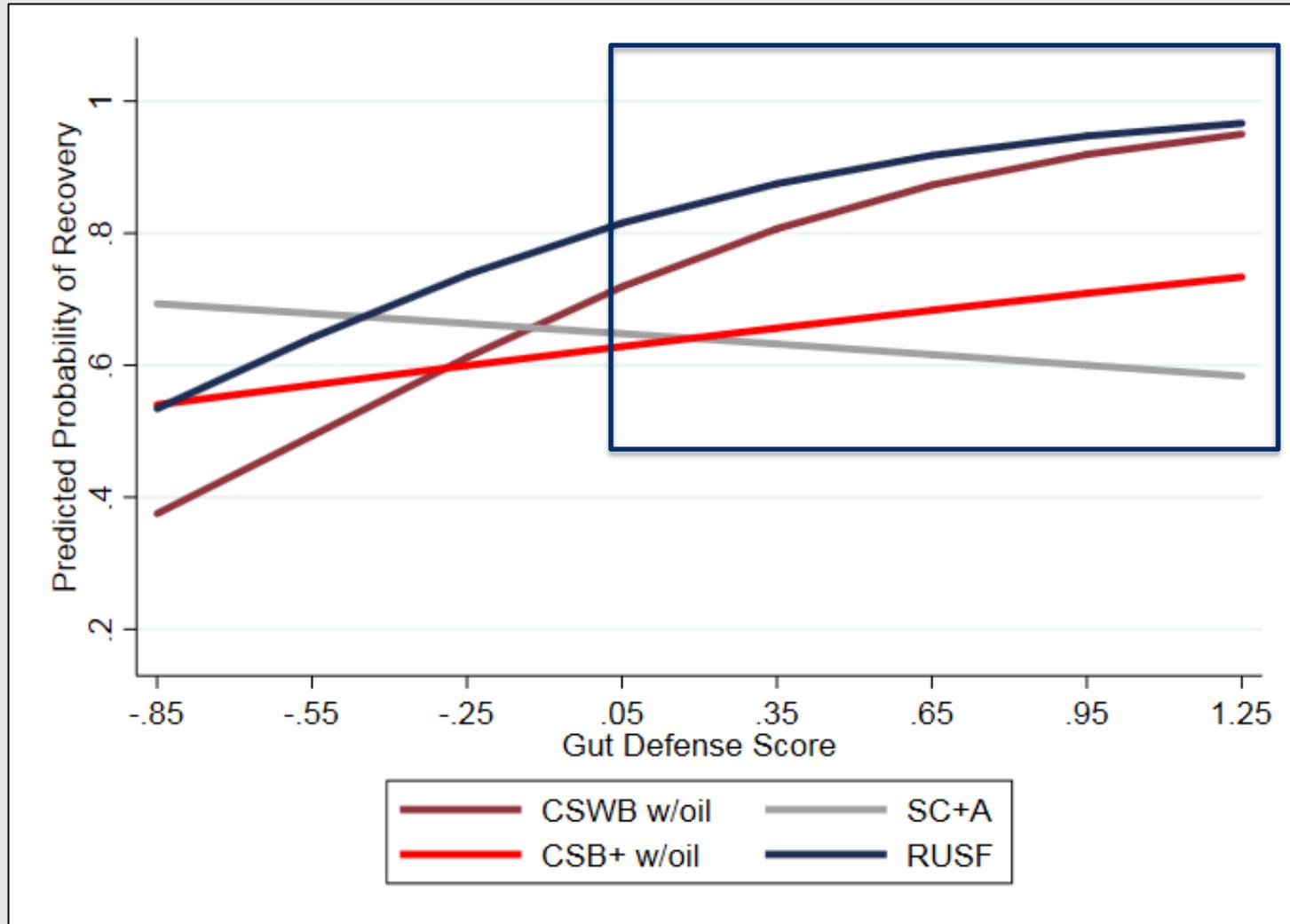
Does any one of the four foods achieve recovery better than another in the presence of EED?

No differences were observed in performance of study foods by level of %L, Gut Inflammation Score, or Gut Structure Score



P-value=0.331

Differences were observed in performance of study foods by level of Gut Defense Score

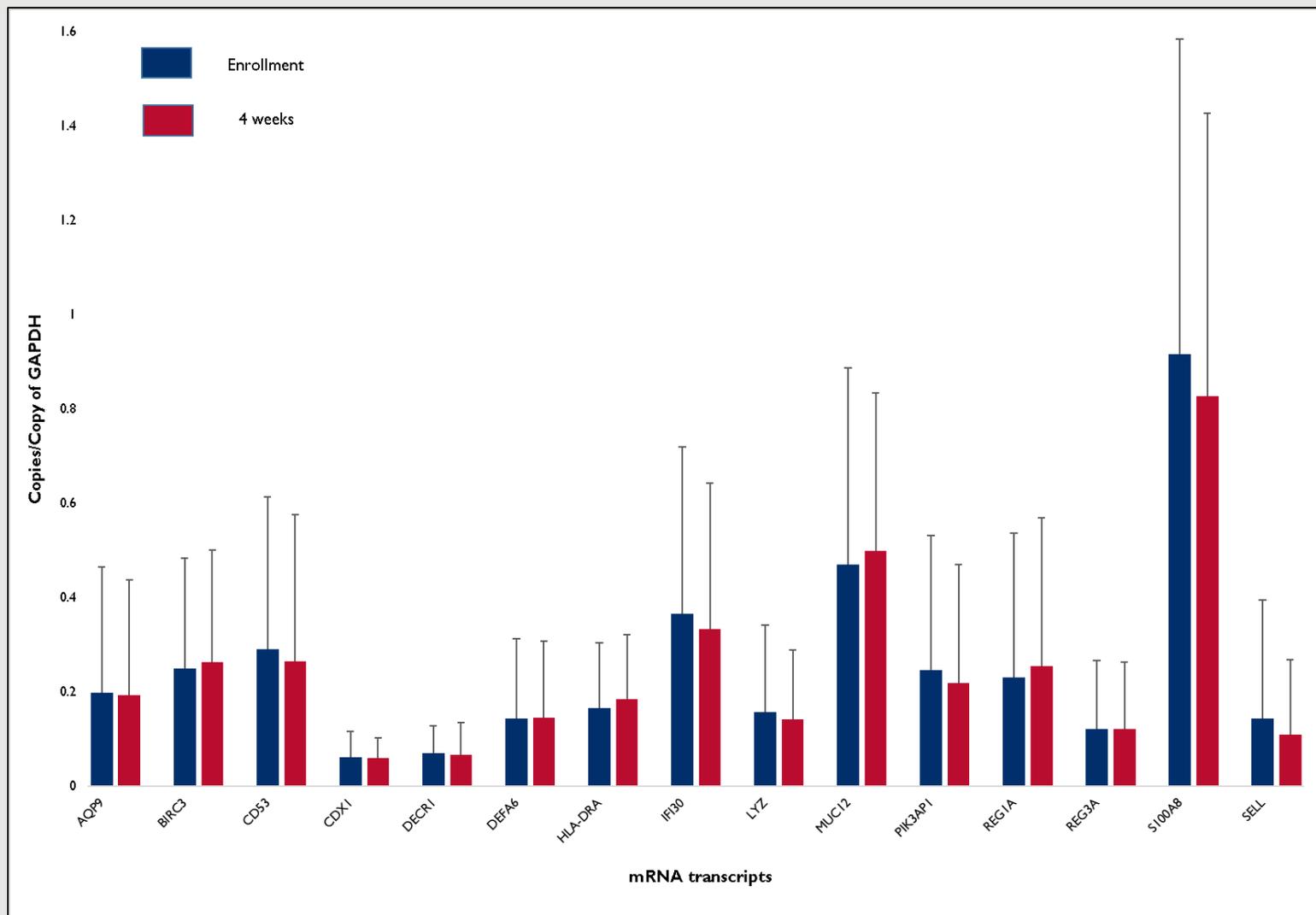


P-value=0.001

Research Question 3

Is there an improvement in EED over four weeks of treatment?
Does any one of the four foods perform differently than another at improving EED?

No change in mRNA transcripts from enrollment to 4 weeks or by study food



n=varies (ranges from 202 to 219)

Summary of findings

- MAM children who start the program with a healthier small intestine are more likely to recover from MAM.
- The study foods performed equally in enabling MAM children with poor intestinal health to recover from MAM.





Introduction and Background: The Four Foods MAM Treatment Study



Results of Main Study

- Comparative Effectiveness
- Cost-effectiveness
- Behavioral Factors Influencing Effectiveness



Three Sub-Studies

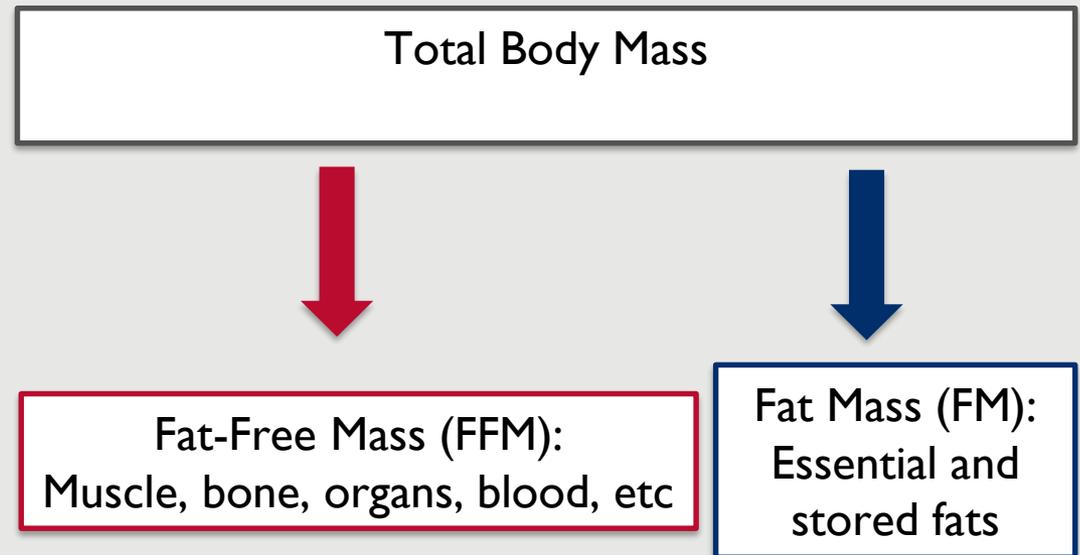
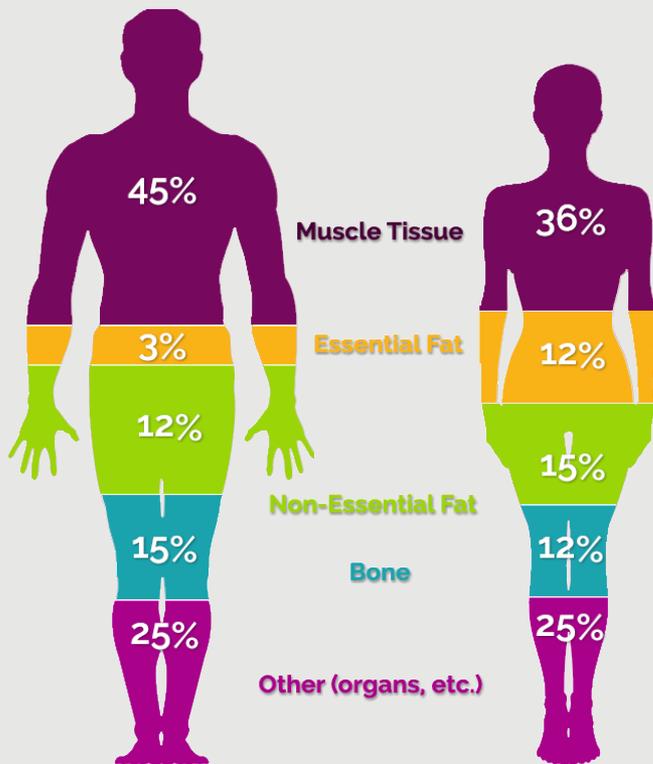
- Environmental Enteric Dysfunction
- **Body Composition**
- Neurocognition



Implications for FFP Programming

Why should we focus on Body Composition?

- Measures of body composition (fat-free mass and fat mass) tell us more about the type of weight gained during supplementary feeding programs and may better represent and predict healthy recovery from MAM



Research questions for Body Composition sub-study

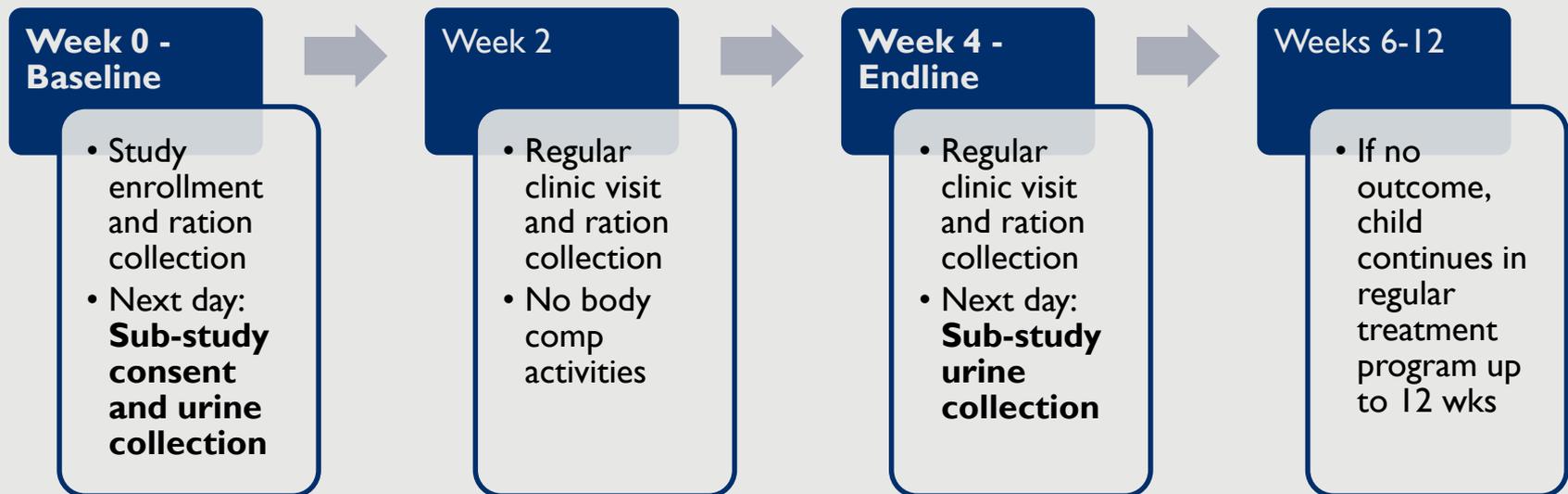
1. What are the changes in body composition (specifically fat and fat-free mass) of 6-59 month-old children with MAM after four weeks of treatment?
2. What is the relation of FM and FFM to MUAC, WHZ and recovery?
3. Are there differences in body composition changes among the four supplementary foods?



We used **deuterium dilution** to measure **Body Composition**

- Deuterium dilution technique used to estimate FM and FFM at enrollment and 4 weeks*
 - Deuterium solution administered orally
 - Urine collected for analysis

* This length of time was used because all children should have received at least 4 weeks of rations regardless of when they graduated



*578 subjects recruited and consented;
516 completed baseline measure*

*407 subjects completed
endline measure*

Research Question I

What are the changes in body composition of 6-59 month-old children with MAM after four weeks of treatment?

The four study arms had comparable anthropometric & body composition measures at baseline

	Total
<i>n</i>	352 ¹
Weight, kg	6.54 ± 0.94 ²
WHZ	-1.71 ± 0.72
MUAC, cm	12.0 ± 0.27
FFM, kg	5.26 ± 0.94
FM, kg	1.28 ± 0.50
FFM % ³	80.3 ± 7.34
FFM index ⁴	11.7 ± 1.18

ANOVA tests used to determine differences among the 4 study arms; $P < 0.05$ for all

¹ 54 subjects removed from analysis due to implausible/influential outlier body composition values

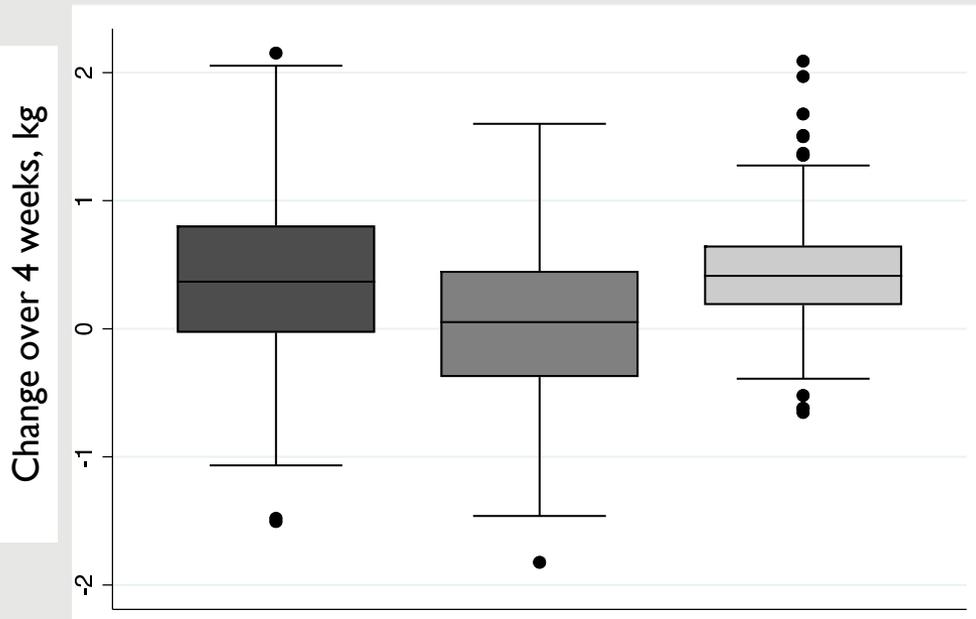
² Mean ± SD, all such values

³ FFM / body weight x 100

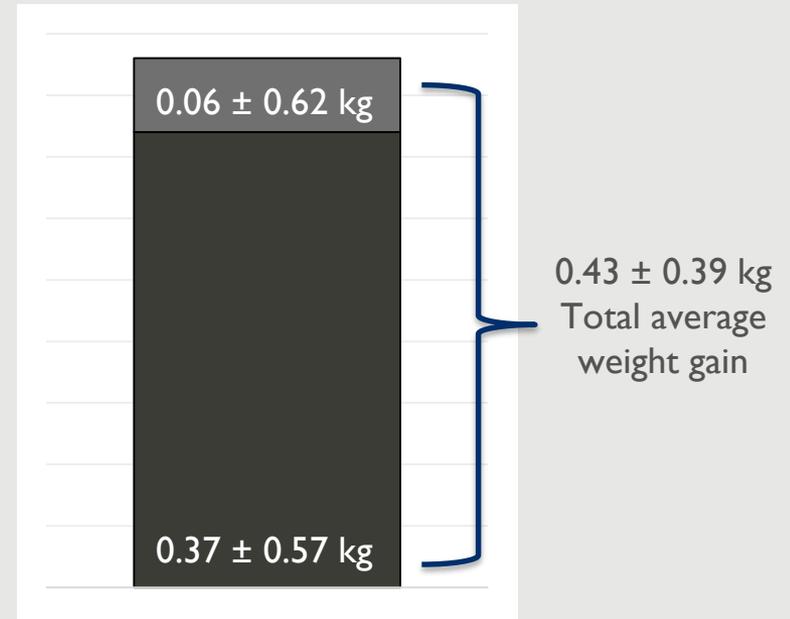
⁴ FFM kg / height²

Changes in FFM, FM and weight after 4 weeks

Among all subjects, changes in FFM and FM after 4 weeks were highly variable



On average, approximately 86% of weight gained was FFM



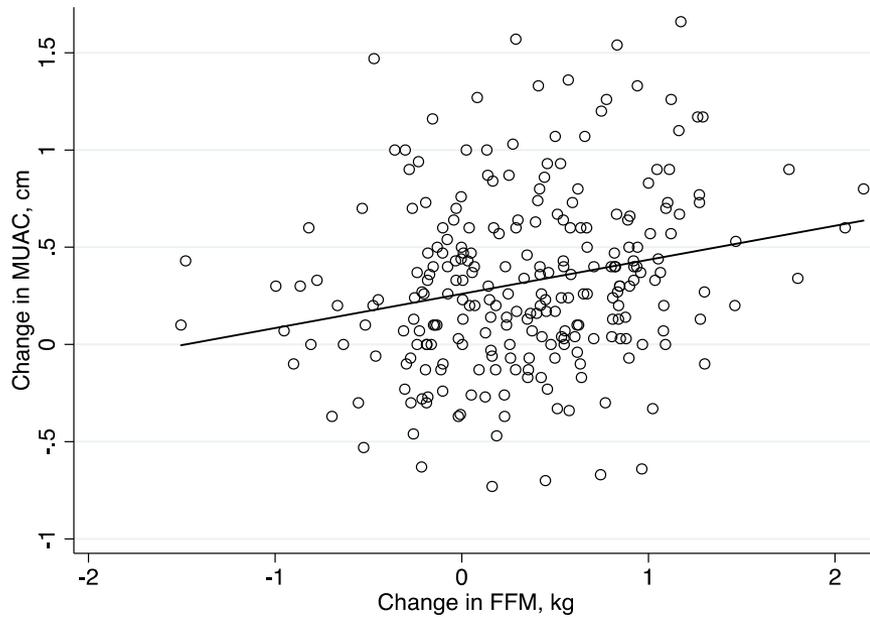
■ Fat-free mass ■ Fat mass ■ Weight

Research Question 2

What is the relation of FM and FFM to MUAC, WHZ and recovery?

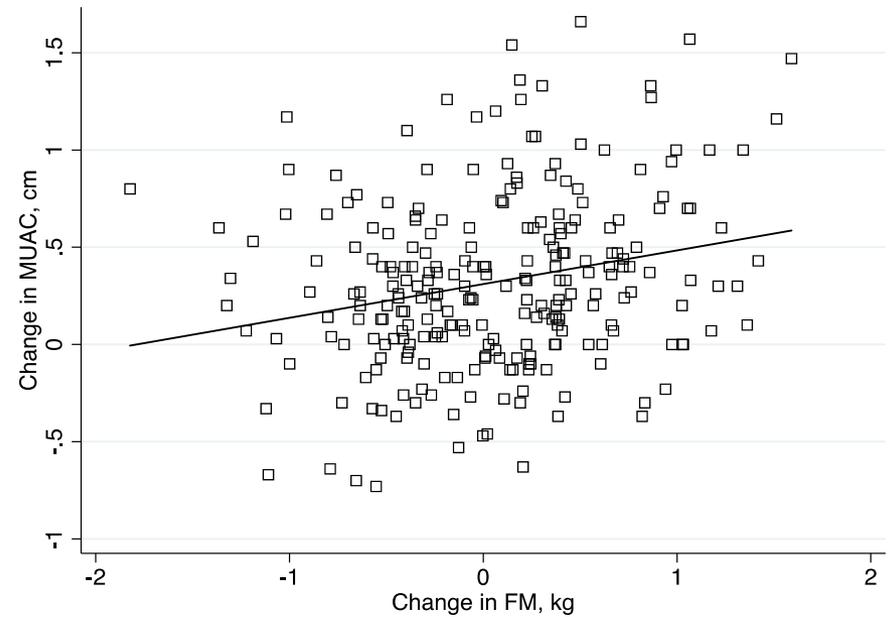
Changes in MUAC and changes in FM, FFM over 4 weeks were similarly, weakly correlated

Change in FFM and change in MUAC



Adjusted R-squared: 0.05
Pearson correlation: 0.23 ($P < 0.001$)

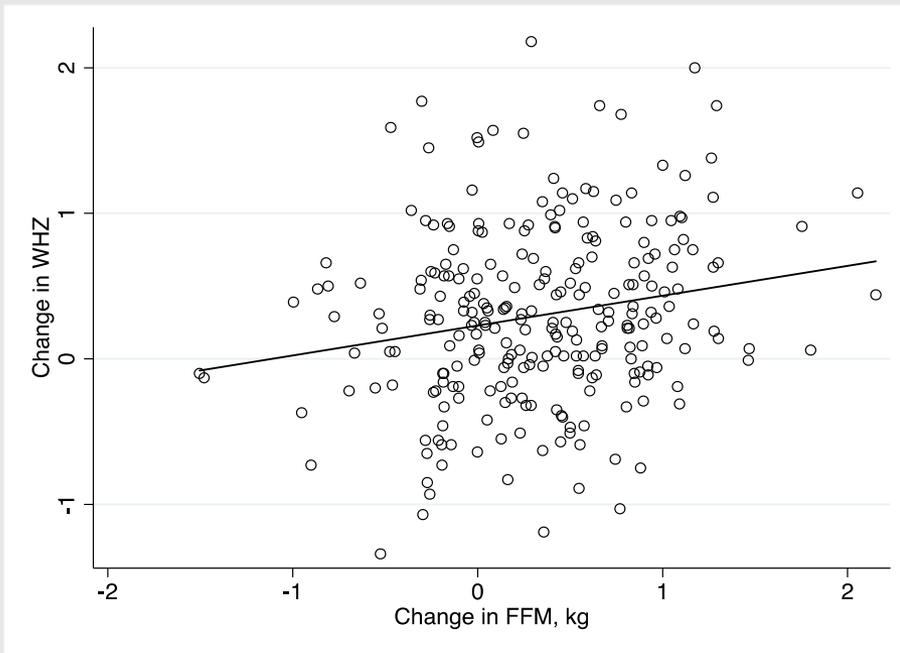
Change in FM and change in MUAC



Adjusted R-squared: 0.05
Pearson correlation: 0.23 ($P < 0.001$)

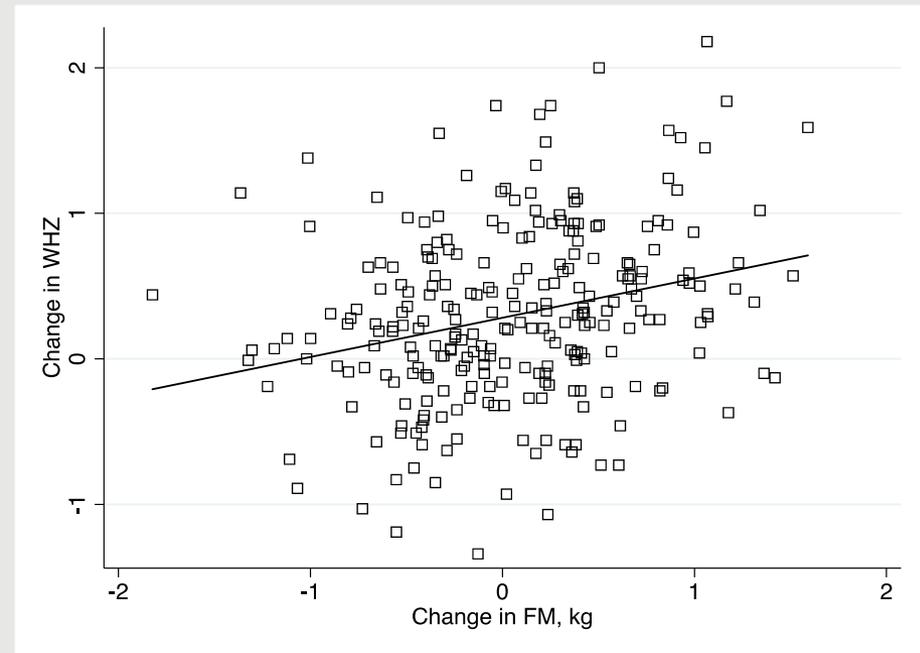
Changes in WHZ and changes in FM, FFM were similarly, weakly correlated

Change in FFM and change in WHZ



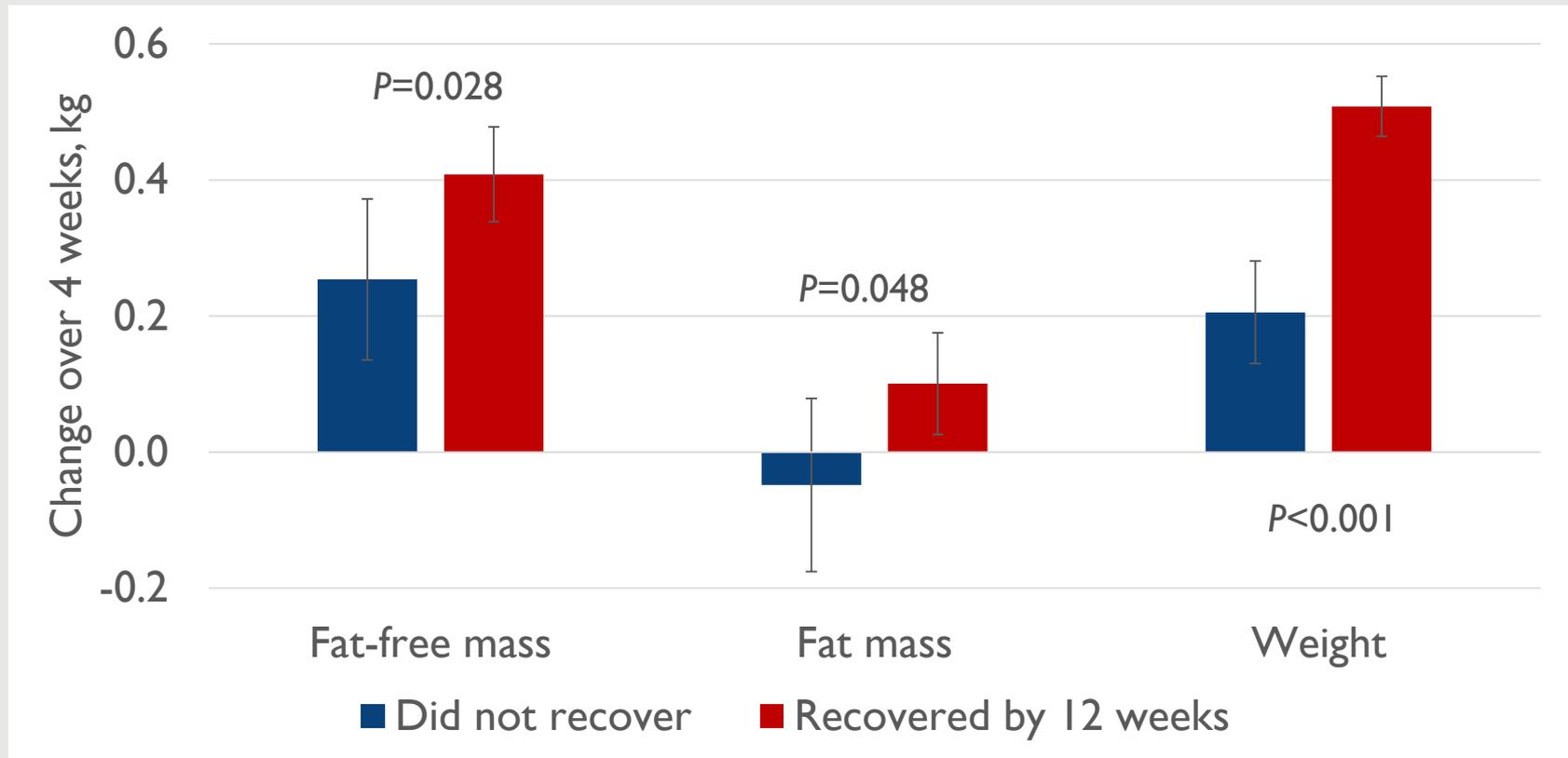
Adjusted R-squared: 0.03
Pearson correlation: 0.20 (P=0.002)

Change in FM and change in WHZ



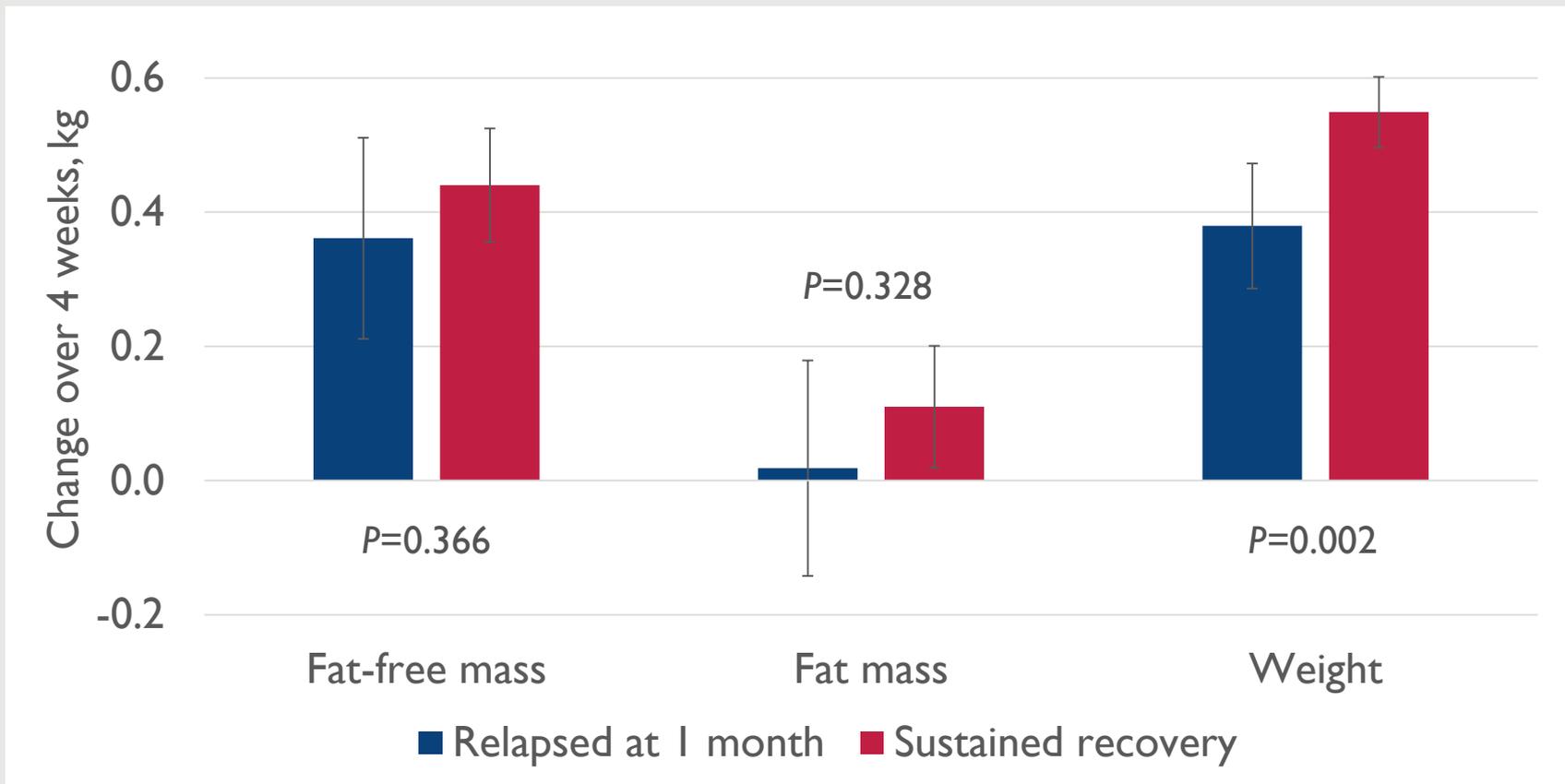
Adjusted R-squared: 0.07
Pearson correlation: 0.27 (P<0.001)

On average, children who recovered by 12 weeks gained significantly more weight, FFM and FM in first 4 weeks



Recovered $n=262$, did not recover $n=90$

On average, children who sustained recovery for one month gained more weight at 4 weeks; FFM and FM were also higher but not significantly

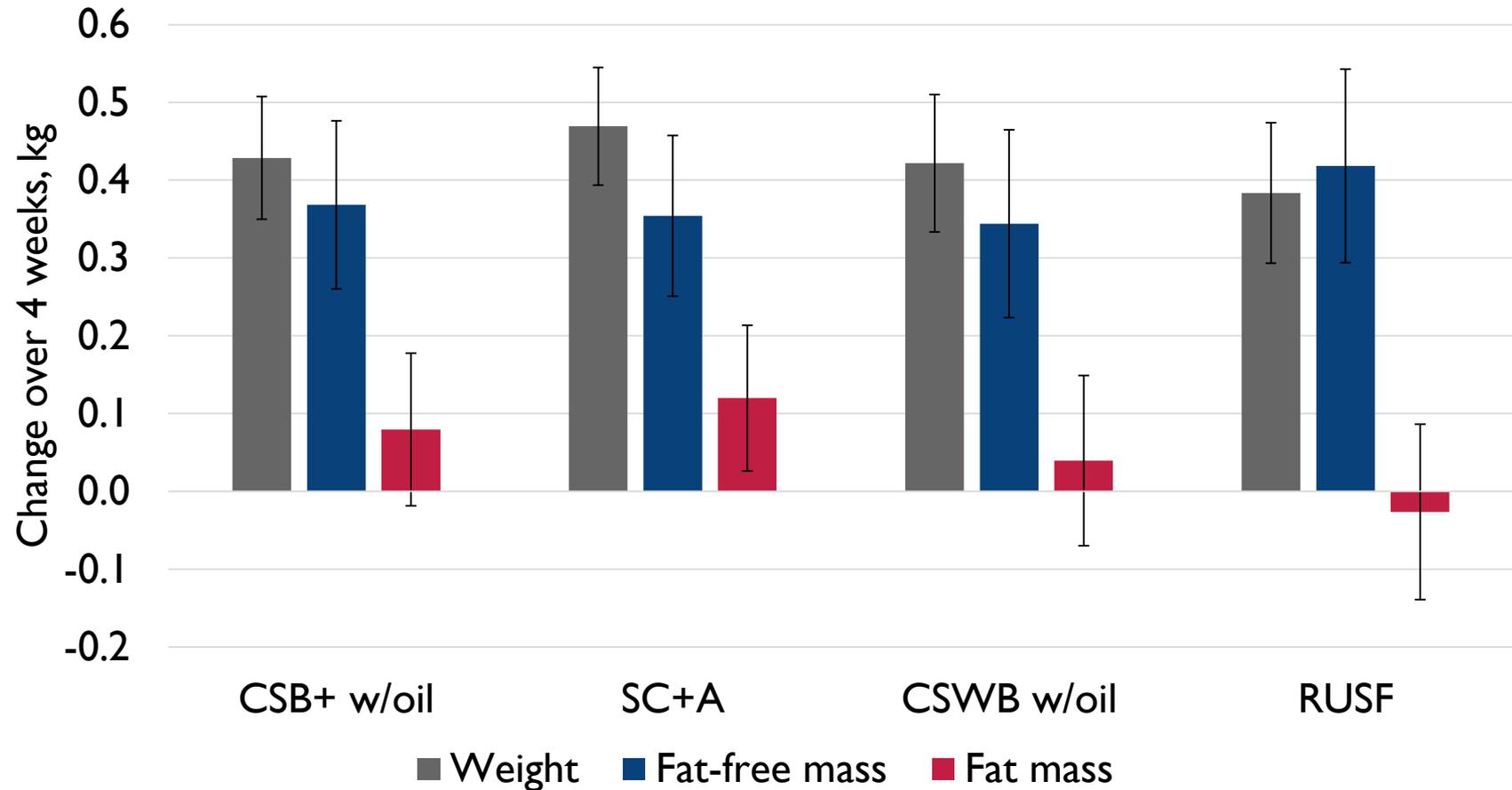


Relapsed at 1 month n=60, sustained recovery n=189, missing n=13

Research Question 3

Are there differences in body composition changes among the four supplementary foods?

No significant differences in body composition changes over 4 weeks of treatment among the study arms



Predicted changes from models adjusted for baseline outcome measure, age, sex, baseline WHZ and wealth quintile; n = 352

Summary of Findings



After 4 weeks of treatment for MAM:

- Children gained mostly FFM on average
- FM and FFM were weakly correlated with anthropometric measures
- Children who recovered were already showing differential changes in body composition at 4 weeks (more FFM and FM); children who sustained recovery showed similar trends
- All four study foods were equivalent in producing changes in FM, FFM and weight



Introduction and Background: The Four Foods MAM Treatment Study



Results of Main Study

- Comparative Effectiveness
- Cost-effectiveness
- Behavioral Factors Influencing Effectiveness



Three Sub-Studies

- Environmental Enteric Dysfunction
- Body Composition
- **Neurocognition**



Implications for FFP Programming

Background

- MAM is a debilitating condition that affects the development and function of multiple organ systems, including the brain.
 - animal & human autopsy data (Brenna, 2011; Cordero et al., 1993)
 - longitudinal data (Galler et al., 2013; Peter et al., 2016)
- Effects on brain function can't be assessed by tape measures. Other indicators needed (Hsieh et al., 2014, Suri & Rosenberg, 2018).
- Measures of brain function that could be used in field and low-resource settings:
 - Direct measures of brain activity (EEG, Near Infrared Spectroscopy)
 - Indirect indicators of brain function: eye tracking

Aims and objectives (neurocognitive sub-study)

1. Assess the feasibility and measurement properties of eye-tracking in 7 to 11-month-old children in low-resource setting
2. Examine the effects of MAM on neurocognitive function in 7 to 11-month-old children.
 - Hypothesis 1: Children with MAM will show neurocognitive slowing (slower saccadic eye movements)
 - Hypothesis 2: Treatment with supplementary food will lead to a recovery of neurocognitive function in MAM.

Methods & Results

Table 1. Sample.

N	Control	CSB+	CSWB	RUSF	SC
Enrolled and tested	60	35	20	39	37
Not eligible	0 (0%)	2 (11%)	0 (0%)	1 (5%)	0 (0%)
Insufficient eye-tracking data	14 (23%)	3 (9%)	8 (40%)	8 (21%)	11 (30%)
Final N	46 (77%)	30 (86%)	12 (60%)	30 (77%)	26 (70%)
Mean Age in Days (SD)	274.4 (41.6)	266.6 (44.6)	259.3 (45.2)	259.4 (37.5)	271.5 (42.1)

- Eye tracking administered twice:
 - upon enrollment to the study/feeding program (i.e., Pretest/Visit 1)
 - four weeks later (post-test/Visit 2).

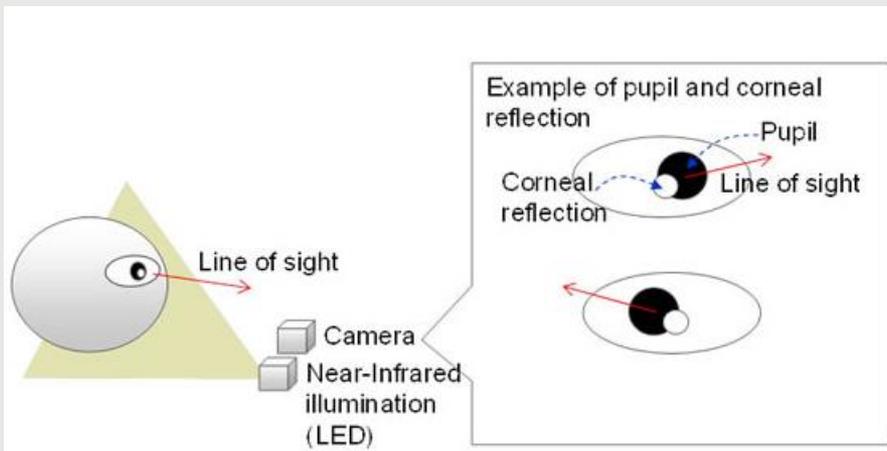
Eye tracking



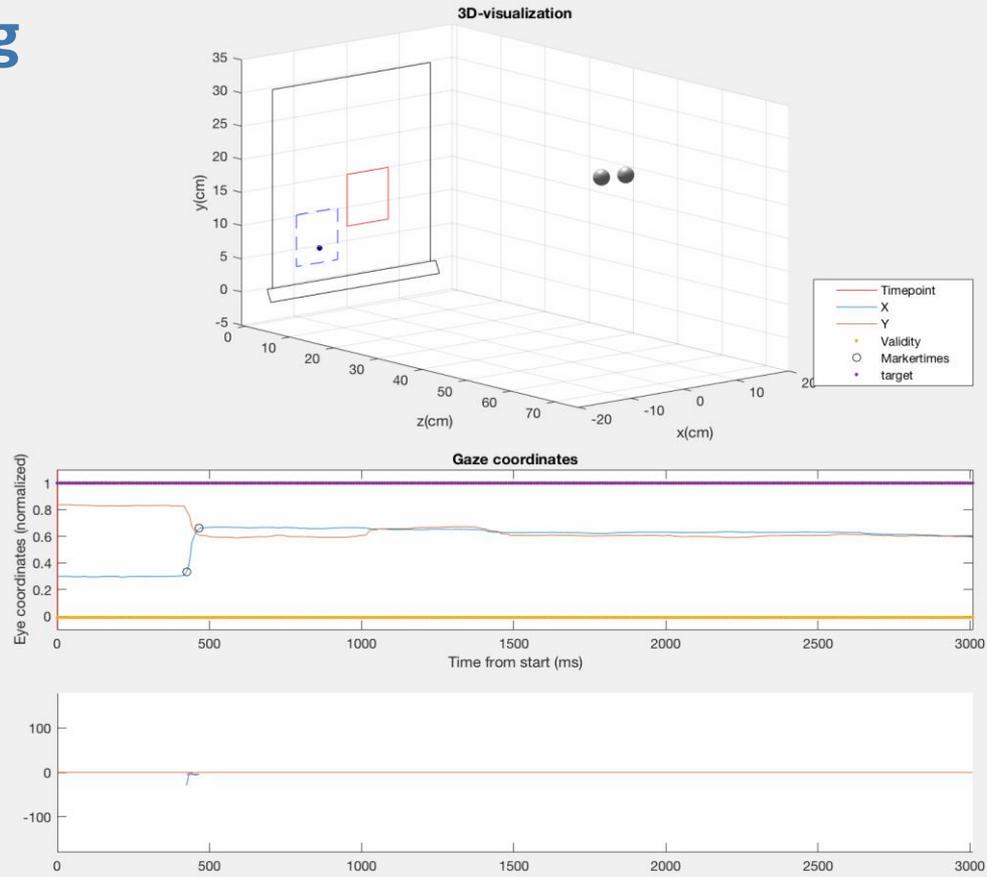
Eye tracking



Eye tracking

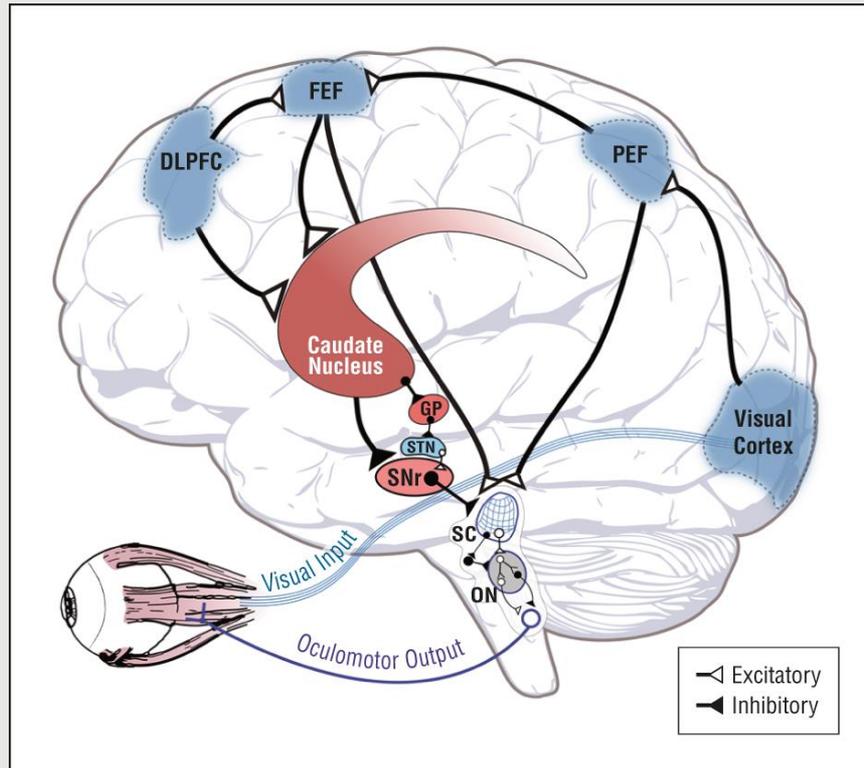


Eye tracking



Saccadic Reaction Time

Repeat-->Mean Saccadic Reaction time



Carpenter; Sharma et al.

Implementation in Sierra Leone

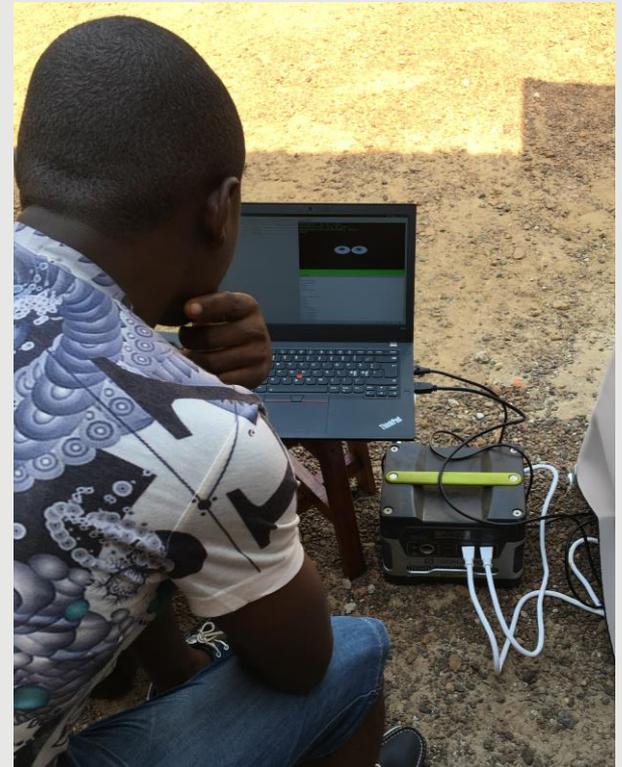
A solar-powered, tent lab.



A child positioned for testing.



Data collector monitoring the testing.

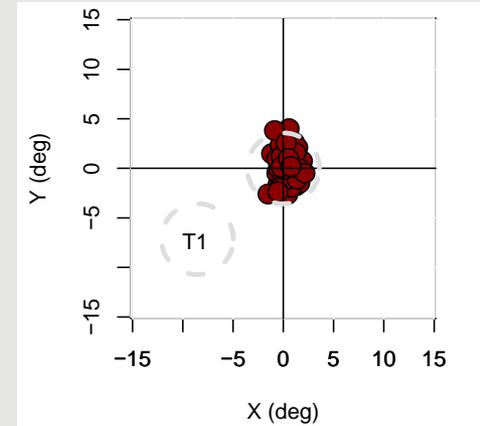


Feasibility

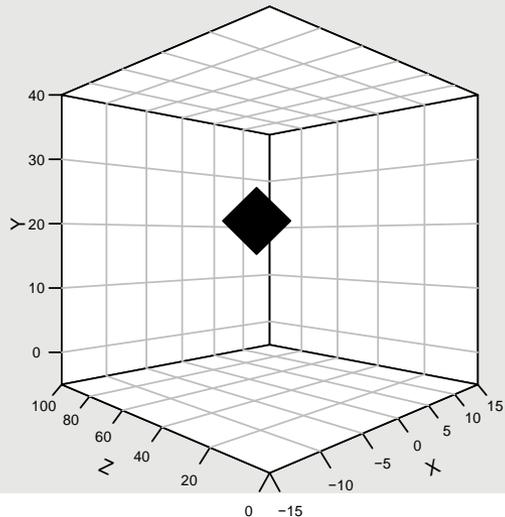
Test success rate

Valid data from 76% for 2 separate measurements at the first attempt of testing on each day

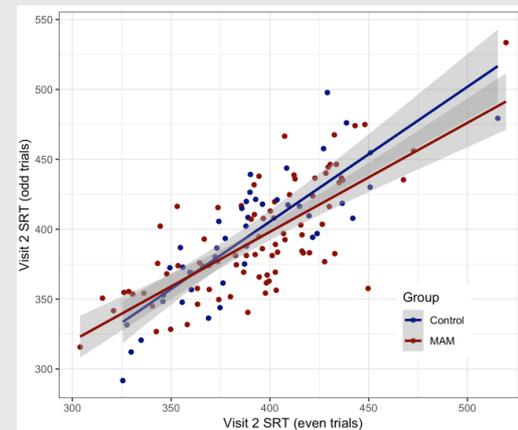
Tracking accuracy



Eye position stability during tracking



Measure repeatability

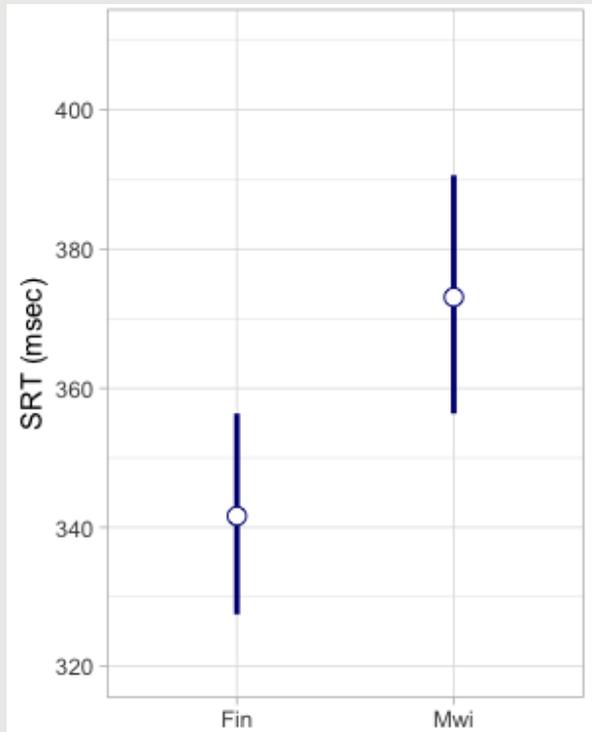


Hypothesis 1: children with MAM are slower than controls

Finland Malawi

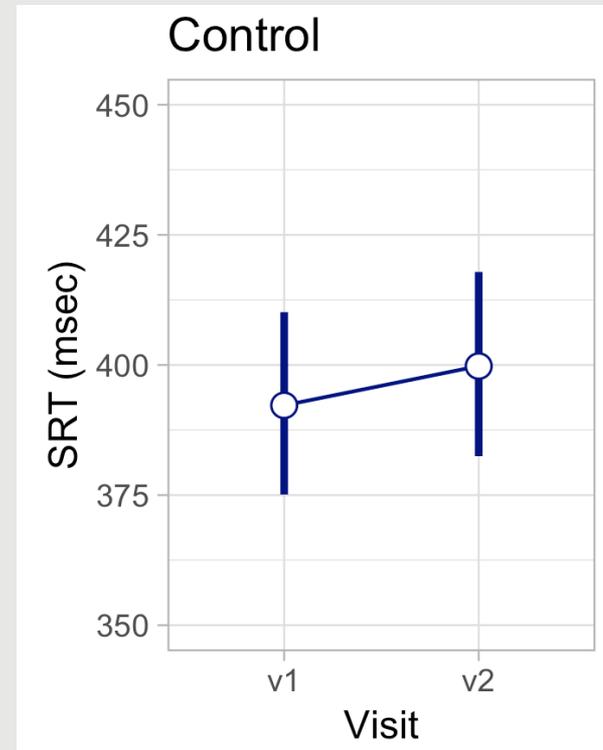
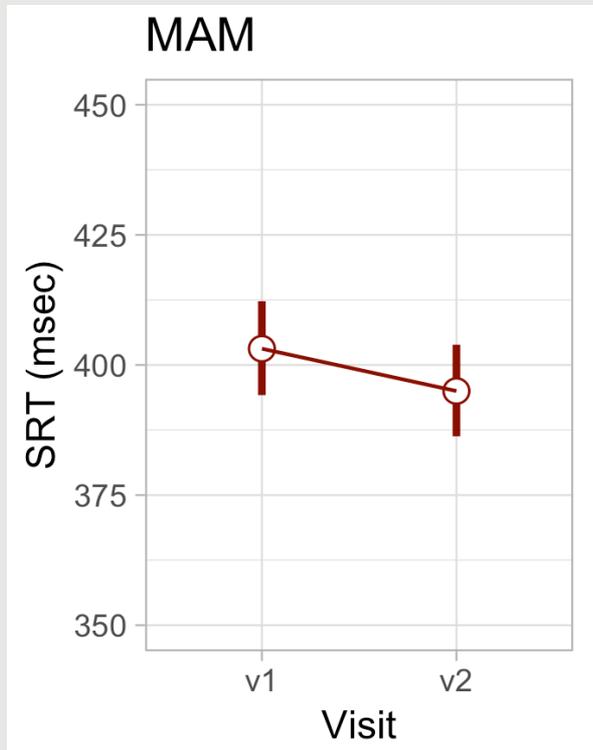
South Africa

Sierra Leone



$$(\chi^2 (1) = 3.64, p = .056)$$

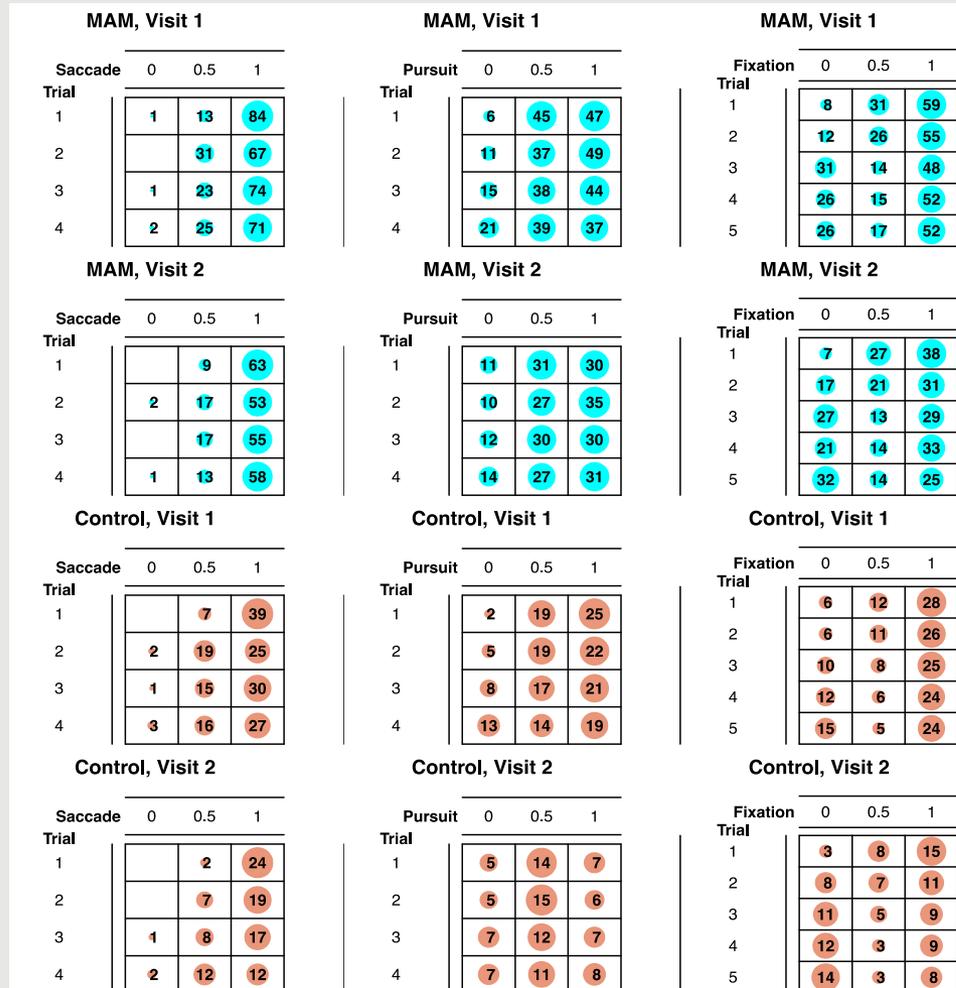
Hypothesis II: Neurocognitive slowing in MAM recovers after supplementary feeding



MAM, ($\chi^2(1) = 9.69, p = 0.002$)

Control, *ns*

Conventional testing



Conclusions

- **Eye tracking was feasible**
 - completion rates slightly lower than expected (76%, expected 81% for two successful tests).
 - key metrics of visual orienting and holding were obtained for most infants
- **Infants with MAM had marginally slower saccadic reaction times than non-MAM controls**
 - Consistent with the hypothesized effects of MAM on neurocognition
 - The effects of MAM may not stand out as a strong effect in resource-poor settings as most children are affected by various poverty-related risk factors in these environments
- **Infants with MAM showed improved visual orienting (saccadic reaction time) and attentional focusing (mean duration of fixations) after four weeks of supplementary feeding**
 - The first direct demonstration of neurocognitive benefits of supplementary feeding in resource-poor settings



Introduction and Background: The Four Foods MAM Treatment Study



Results of Main Study

- Comparative Effectiveness
- Cost-effectiveness
- Behavioral Factors Influencing Effectiveness



Three Sub-Studies

- Environmental Enteric Dysfunction
- Body Composition
- Neurocognition



Implication for FFP Programming

Implications for Food for Peace Programming

1. Selection of the treatment food should be based on cost and feasibility, given that the foods performed comparably across metrics
2. Quality of program implementation relating to the delivery modality is a critical determinant of a program's effectiveness and cost-effectiveness
3. We need to think beyond anthropometry at other indicators of recovery
4. Empirical observations of household behavior provide important insights into determinants of program effectiveness and cost-effectiveness

Implication I: Program-Specific

- I. Selection of the treatment food should be based on cost and feasibility, given that the foods performed comparably across metrics**
 - There was no statistically significant difference in recovery rates across the four foods.
 - The four foods were similarly cost-effective measured in cost per recovered child.
 - Caregivers' opportunity costs differed by food but did not alter the comparative cost-effectiveness of the four foods when combined with program perspective.
 - There were no differences in change in body composition by food
 - There was no difference in recovery rates across the foods among children with EED
 - Including sustained recovery in the cost-effectiveness analysis reduced the relative cost-effectiveness of RUSF.

Implication 2: Program-Specific

2. Details of program implementation relating to the delivery modality are critical determinants of a program's effectiveness and cost-effectiveness

- The mobile-SFP's operational costs were the largest cost contributors but operational cost of MAM SFP's are generally high.
 - Food-specific costs were not the largest cost contributors.
- Smaller sized packaging for FBFs is slightly more expensive but also more efficient.
- Program implementation is not only food delivery but includes additional services such as counseling, promotion of good WASH practices, and positive behavior change.

Implication 3: Program-Specific

3. We need to think beyond anthropometry at other indicators of recovery

- Sustained recovery at 1-month was lowest in the RUSF arm compared to FBFs
 - Children who sustained recovery tended to gain more FFM, FM and weight over the first 4 weeks of treatment
- Changes in body composition were poorly correlated with anthropometric measures
 - Changes in FFM, FM and weight in the first 4 weeks of treatment were significantly different between recovered and not recovered children within 12 weeks of treatment
- Cognitive performance is lower in malnourished children
 - Malnourished children could reach the level of their well-nourished peers after just 4 weeks of treatment
- Supplemental feeding was correlated with improvements in EED

Implication 4: Household-Specific

4. Empirical observations of household behavior provide important insights into program effectiveness and cost-effectiveness

- Sharing was observed equally among all foods
 - Sharing was not a predictor of recovery
- Following the recommended recipe did not predict recovery
- Consumption by the beneficiary child was observed in a larger percent of households whose children graduated compared to failed
 - Dietary diversity was slightly different between FBFs and RUSF
- Presence of EED did modify the effects of the study foods on recovery
 - A larger percent of children with EED were observed to put soil/stone in their mouth, lived in households where the drinking water was uncovered, and where animals were observed drinking from the drinking water

Thank you!!

