Evaluation of the family-led MUAC component of an integrated package of interventions to reduce wasting in Chad and Mali

Loty Diop, Elodie Becquey, Ampa D Diatta, Mariama Touré, Talla Fall, Moctar Ouedraogo, Abdoulaye Sawadogo, Lieven Huybregts

Key Findings

- Family-led MUAC, where caregivers and other household members screen their own children regularly to detect child wasting early-on, is a promising strategy to boost screening coverage leading to more children with wasting to be referred and enrolled in available treatment services.
- In settings with regular active screening for wasting by community care groups in Chad and Mali, family-led MUAC had limited reach and effectiveness, thus contributing few additional cases detected, referred, and enrolled in wasting treatment services.
- The introduction of family-led MUAC remained below expectation because the anticipated monthly home visits (main delivery platform) represented too much of a workload for volunteers. Monthly group sessions can be a suitable platform to train households to apply family-led MUAC on the condition that the attending number of caregivers per session is capped to allow for a more individualized approach.
- Less than half of the households disposing of MUAC tapes screened their children monthly. The main reason reported for non-adoption was lack of knowledge and confidence on how to conduct the measurements, which calls for better training of caregivers and more social support to conduct the measurements.
- Both the inadequate introduction by community volunteers, as well as the poor adoption by households of family-led MUAC resulted in a low reach of monthly screening by households (up to 10% in Chad and up to 25% in Mali).
- Caregivers were able to measure their children's MUAC accurately, and caregiver knowledge of family-led MUAC was moderate (Mali) to very high (Chad).
- The short duration of the IRAM program (7-9 months), due to the COVID-19 crisis, may have hampered a continuous learning process leading to improvement of family-led MUAC over time.

I.   Rationale

Globally, child wasting affects 45 million children at any given time, despite its treatment being highlighted among the most cost-effective health interventions to reduce child mortality [1,2]. A recent pooled analysis using the most recent demographic health surveys and Multiple Indicator Cluster surveys from 94 low-middle-income countries found a global prevalence of 14% of wasting for children under two years old and 9% for children 2–4 years old [3]. Therefore, it is doubtful that the 2025 target set by the World Health

Assembly of reducing wasting prevalence to below 5% will be reached. In many settings, outpatient treatment programs to treat children with severe wasting are in place and yield high recovery rates, however, the treatment coverage of these programs remains as low as 17% [4]. Therapeutic supplementary feeding programs to treat moderate wasting are only present in areas with higher wasting prevalence and are contingent on external donor funding. One of the critical barriers to poor treatment coverage is the low detection coverage and associated lack of awareness of a wasted child's condition [5,6]. In response to this observation, the 'family-led MUAC approach was developed to train and encourage mothers, fathers, and other household members to identify wasting in their children using a mid-upper arm circumference (MUAC) tape [7].

The Integrated Research on Acute Malnutrition (IRAM) is a partnership between the International Food Policy Research Institute (IFPRI) and the United Nations Children's Fund (UNICEF). The study was conducted in four countries, including Chad and Mali. Its objective in these two countries was to assess a package of interventions aiming at strengthening the continuum of care of wasting from prevention, screening, referral, to treatment and the post-treatment prevention of relapse. The package of interventions was implemented by ASRADD in Chad and World Vision in Mali in collaboration with the health system and other stakeholders. To increase the coverage of screening for wasting, the intervention package introduced Family-led MUAC. This approach focuses on early detection of child wasting and consists of training primary caregivers and other family members to screen their children for wasting at the household level using MUAC measurements. Previous studies showed that lightly trained caregivers could take accurate MUAC measurements non-inferior to measurements made by trained community health workers (CHWs) [7]. For IRAM, Family-led MUAC was introduced as a complementary approach to the existing active and passive screening carried out by community health workers/volunteers and health staff. The overall objective of combining family and community approaches was to ensure the timely screening of children at affordable costs [8].

II.   Description of the IRAM package of interventions and its Family-led MUAC component

In Chad and Mali, the IRAM package of interventions included the strengthening of community volunteers' activities to reinforce the screening of wasting at the community level. The package of interventions included: 1) the distribution of nutritional supplements such as Corn Soy Blend (CSB++) in Chad and small-quantity lipid-based nutrition supplements (SQ-LNS) in Mali to prevent malnutrition; 2) counseling and Behavioral Change Communication (BCC) to caregivers and family members during home visits; and 3) and culinary demonstrations. The community volunteers, called Community Care Groups (CCGs) in Chad and Nutrition Activities Support Groups (NASGs) in Mali were also responsible for the family-led MUAC intervention in both countries. For this purpose, child caregivers and other family members were provided with colored MUAC tapes (**Figure 1**). They were trained by NASG or CCG volunteers to screen their children 6-59 months of age weekly. The training was conducted during home visits and monthly village gatherings organized by NASGs or CCGs. Caregivers and other family members were invited to demonstrate their screening capability using MUAC to NASG or CCG volunteers during recurrent contacts. NASG or CCG volunteers were also tasked to explain the interpretation of the colors and the procedure to follow if the child was diagnosed as wasted by a family member, which was to go to the nearest health center or community health worker to seek enrollment of the child in outpatient therapeutic programs (OTP) to treat severe acute malnutrition (SAM) or moderate acute malnutrition (MAM).
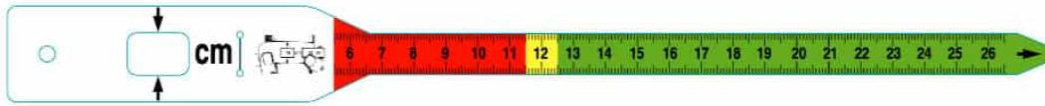
Figure 1: MUAC tape provided to households in Chad and Mali. The red area indicates a MUAC lower than 115mm (Severe Acute Malnutrition, SAM). The yellow color represents MUAC values between 115 and 125mm (Moderate Acute Malnutrition, MAM). The green area indicates MUAC values over 125mm (no wasting).

Community volunteers in Chad and Mali

Community care groups (CCGs)

In 50 randomly-selected villages in the health district of Mongo in Chad (the intervention group), up to fifteen volunteers from a community formed a community care group, with a coverage radius of 15 to 20 households per volunteer. Household eligibility for prevention activities was based on the 1,000-day window: any household with a pregnant woman or a child under the age of two was eligible.

Nutrition Activities Support groups (NASGs)

In half of the Koutiala region in Mali (the intervention group), after a census of all households, the number of NASGs was increased to be proportional to the size of each village (rather than a standard number of 10 to 15 members per village in the comparison group) and each pair of NASG members was allocated 30 households to follow.

Services provided by CCG and NASG

CCG and NASG volunteers were trained and monitored to conduct monthly home visits to eligible households to provide individual counselling, screen children between 6 and 59 months of age, introduce and monitor the family MUAC approach and deliver a monthly ration of food supplements to children aged 6-11 months (Chad) or 6-17 months (Mali). Children that were identified with wasting were not to be given preventive supplements (CSB++ in Chad and SQ-LNS in Mali) but referred to Outpatient Treatment Program (OTP) for Severe Acute Malnutrition (SAM) or Moderate Acute Malnutrition (MAM) instead.

III.   Study design and methods

Data collection

The impact of the IRAM intervention package on child wasting was evaluated using a cluster-randomized, nonblinded effectiveness trial randomly allocating 100 village groups in Chad and 45 health center catchment areas in Mali to either the IRAM intervention group or a comparison group. We used a population-representative longitudinal study design and enrolled 1,586 children in Chad and 2,324 children in Mali aged 6 to 6.9 months from May 2021 until November 2021. Follow-up data were collected monthly until children reached the age of 12 months or by February 2022 (end of the program) on program

exposure, knowledge, practices, and the target child's nutritional status. In addition to the impact evaluation survey data, we collected qualitative data through structured observations of service delivery, in-depth interviews with beneficiaries, NASG, and CCG volunteers, and focus group discussions with NASG/CCG and community leaders.

RE-AIM framework and analysis

We use the RE-AIM framework to evaluate the Family-led MUAC approach implemented in Chad and Mali. This framework has been developed for assessing public health interventions through 5 dimensions: Reach, Effectiveness, Adoption, Implementation, and Maintenance [9]. RE-AIM has been found to be efficient for planning and evaluating community-based projects [10]. The operationalization of RE-AIM with regard to assessing the family-led MUAC approach is presented in **Table 1**.

Table 1: Research questions and indicators used to evaluate the Family-led MUAC component of the IRAM intervention through the RE-AIM framework [11]

	Adoption	Implementation	Reach	Effectiveness	Maintenance
Research Question	How well do household members adopt Family-led MUAC?	What is the quality of Family-led MUAC implemented by household members?	What is the reach of screening for wasting by Family-led MUAC?	- How effective is Family-led MUAC screening?	- Is the Family-led MUAC approach sustainable?
Secondary research questions	- What are the drivers and barriers of the adoption of family-led MUAC by household members? - Which subgroups of the target population of households and caregivers adopt family-led MUAC?*	What are the drivers and barriers of the quality of Family-led MUAC implemented by household members?	What is the reach of screening for wasting by Family-led MUAC compared to other actors who screen?	- What are the barriers to the effectiveness of Family-led MUAC screening? - How effective is Family-led MUAC screening compared to other actors who screen?	- What are the drivers of the sustainability of Family-led MUAC?
Operationalization	- Proportion of home visits with HH members asked to screen their child under the supervision of CCG/NASG (setting level) - Proportion of HH having received a MUAC tape (setting level) - Proportion of HH who received MUAC tapes that screen their children monthly (individual level) - Reasons for HHs to (not) screen their children	- Frequency of measurement by family-led MUAC per month - Accuracy and precision of the caregivers' MUAC measurements against anthropometry expert's measurement - Caregiver knowledge of family-led MUAC - Observations of the quality of measurements implemented by household members (qualitative observation data)	- Proportion of children screened by family-led MUAC (individual setting) - Proportion of children screened by family-led MUAC only. - Proportion of children screened by family-led MUAC and non-household actors. - Proportion of MAM/SAM children screened by family-led MUAC only. - Proportion of MAM/SAM children screened by family-led MUAC and non-household actors.	- Proportion of MAM/SAM children (self-)referred to treatment by family-led MUAC - Proportion of admissions to treatment following self-referral by family-led MUAC - Reason for effectiveness (qualitative data) - Household members satisfaction on the use of MUAC (qualitative data)	- Is Family-led MUAC sustainable (qualitative data)? - What external support is necessary to make Family-led MUAC sustainable?

An additional analysis was conducted to identify factors that determine the adoption of the Family-led MUAC approach in the households. A list of potential indicators considering known and hypothesized associations was compiled for both Chad and Mali (Appendix 1).

IV.   Results

Adoption

Under the adoption dimension, we assess to what extent caregivers and other household members have put the family-led MUAC into practice. Because this adoption by caregivers is conditional on the introduction of the family-led MUAC by NASG and CCG delivering the intervention, we first look at the programmatic adoption by CCG and NASG members.

Introduction of Family-led MUAC by CCGs and NASGs

In both countries, community health workers (CCG volunteers in Chad and NASG volunteers in Mali) adopted the family-led MUAC approach in the IRAM intervention groups. Up to 72% (Chad) and 85% (Mali) of the home visits conducted by volunteer workers included a demonstration of MUAC measurement techniques to caregivers or other family members interested (**Table 2**). During six out of 10 home visits, caregivers or other family members were asked by NASG/CCG volunteers to perform MUAC screening, as requested by protocol, to assess – and correct as needed – the measurement technique used by household members. However, the level of home visits conducted by CCGs and NASGs remained below expectation, with only 8-10% of intervention households receiving a monthly home visit. In both countries, NASGs and CCG volunteers found the number of monthly home visits requested by the program incompatible with their agricultural labor and domestic work.

Table 2: MUAC screening and family-led MUAC coverage during home visits by CCG/NASG volunteers in Chad and Mali

	Chad		Mali	
	Comparison group	IRAM Intervention	Comparison group	IRAM Intervention
	n=4,602	n=4,630	n=5,215	n= 5,795
Received a home visit by CCG/NASG in past 30 days	34 (0.74%)	358 (7.7%)	95 (1.8%)	602 (10%)
Program services delivered during home visits	n= 34	n= 358	n= 95	n= 602
MUAC of the child measured by CCG/NASG	24 (71%)	313 (87%)	86 (91%)	540 (92%)
Demonstration by NASG/CCG of MUAC measurement	17 (50%)	256 (72%)	67 (71%)	498 (85%)
MUAC taken by family during home visits	14 (41%)	228 (64%)	23 (24%)	390 (65%)

To compensate for the low level of home visits, CCGs and NASGs introduced the family-led MUAC during monthly gatherings, along with BCC activities and the distribution of the CSB++/SQ-LNS supplements. Indeed, in both countries, monthly gatherings in the IRAM communities reached a larger proportion of children (38-39%) than home visits. In Chad, caregivers were trained by CCG in measuring their children's MUAC in only 4 of 15 observed group sessions and in 8 of the 15 sessions, the CCG volunteers themselves screened the children. In Mali, we observed NASG volunteers introducing family-led MUAC to caregivers in 5 of 7 observed group sessions, but these sessions were held towards the end of the program. A proxy indicator to assess the adoption of family-led MUAC by NASG/CCG volunteers is the proportion of households having received a MUAC tape. We found that, by the end of the study, only 40% and 60% of households in Chad and Mali, respectively, had a program provided MUAC tape (**Figure 2**). We can therefore conclude that family-led MUAC was not fully introduced by CCG and NASG.
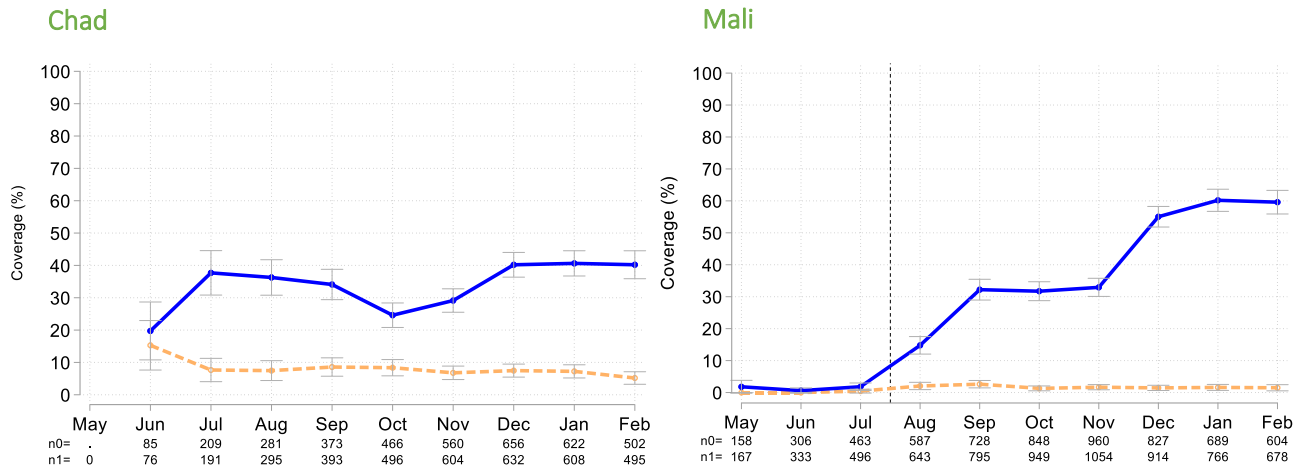
Figure 2: Proportion of households that received a MUAC tape in Chad and Mali by month from May 2021 to February 2023. n0 and n1 represents the sample sizes per month respectively for the comparison and the intervention groups. The solid blue line represents the IRAM intervention group, whereas the dashed orange line represents results from the comparison group.

Adoption by caregivers and other household members

In households that received a MUAC tape, the proportion of children screened for wasting by any household member was stable at around 40-45% in Mali. In Chad, adoption by households varied, with a peak at 45% in the second month of implementation to lower values in the months thereafter, resulting in an average adoption rate of 28% (**Figure 3**). Screening in the households was mainly carried out by the primary child caregiver in both Chad and Mali. On average, 93% and 91% of children screened by family-led MUAC were solely screened by their primary caregiver. These data suggest that the program could not reach other household members to involve them in family-led MUAC or that other household members were not sufficiently motivated to be involved in screening of children in their household. In-depth interviews with caregivers showed that although the direct involvement of other family members was low, their positive views and support were essential for caregivers' adoption of family-led MUAC. Several household members provided support to caregivers in the form of reminders to measure the child's MUAC.

In Mali and Chad, an important barrier to the adoption of MUAC screening by households was a lack of knowledge or confidence expressed by caregivers in their ability to measure their child's MUAC (**Figure 4**). This is likely the consequence of village gatherings having replaced home visits as the main delivery platform of the family-led MUAC approach. Effective training of caregivers in village gatherings proved challenging due to the large groups of participants (up to 50-70 caregivers per gathering) and multiple activities. In some cases, NASG members screened the child themselves instead of inviting the caregiver to demonstrate her performance to measure their child's MUAC. This barrier did not emerge as often in the in-depth interview results, which predominantly reported caregiver's limited time availability or forgetfulness.

"I don't use it too frequently, our occupations are too much, that's why we rarely use. Now we go to the field, when we finish preparing, we go to the field directly. Sometimes you remember this, but sometimes you don't" [Caregiver – IRAM intervention group Mali]
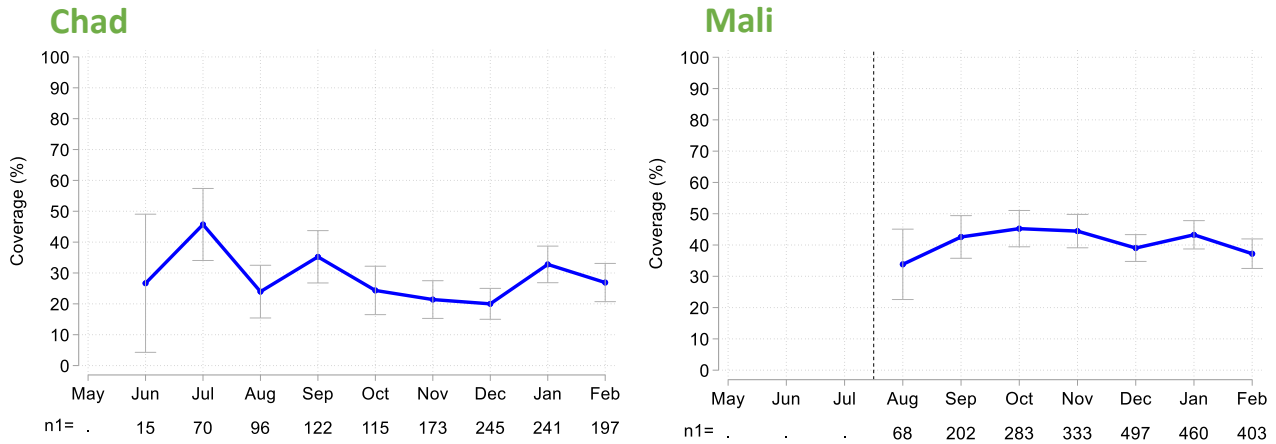
Chad

Mali

Figure 3: Proportion of children screened by family-led MUAC in the subgroup of households that had received a MUAC tape in the IRAM intervention group. n1 represents the number of households that had a MUAC tape. The vertical dashed line in the right panel indicates the start of the program in in Mali.
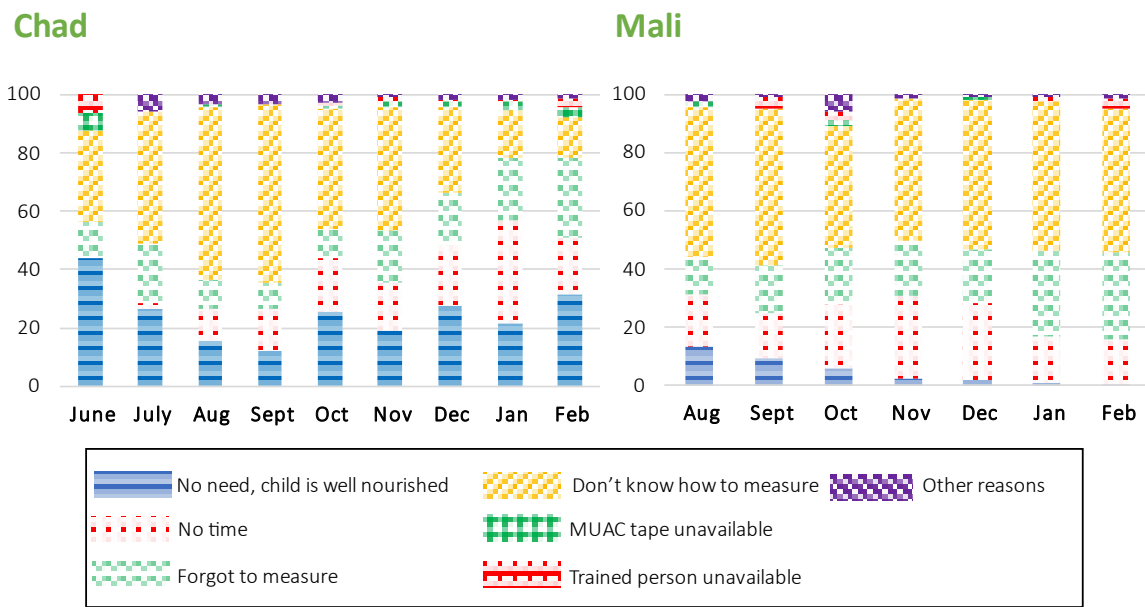
Chad

Mali

Figure 4: Reasons given by caregivers on why the child's MUAC was not measured in the household during the past month in Chad and Mali.

"I take [the MUAC measure] with his left arm (demonstration). It's been a while since I took his MUAC. I'm so busy that I can't make time to take his MUAC; I spend more time doing field work, that's why". [Caregiver – IRAM intervention group Chad]

In Chad, the main barrier being lack of knowledge on how to conduct family-led MUAC diminished in importance over time. Caregivers who received a MUAC tape were asked to bring it to the monthly distribution of the nutrition supplements where they were asked to demonstrate their measurement before a CCG member, which may have gradually improved their performance.

"At the very beginning it's a bit complicated [to measure the MUAC], but now I've got the hang of it, I can do it easily". [Caregiver – IRAM intervention group Chad]

Finally, in Chad, compared to Mali, a greater percentage of mothers reported not measuring the child because they did not feel the need – the child looked well-nourished to them.

To have a better understanding of the reasons for (non)adoption of the family-led MUAC approach, we conducted a determinant analysis to identify associated factors. The bivariate analysis first identified a large set of potential determinants which were mainly related to the caregiver's characteristics, services delivered by IRAM intervention through CCGs and NASGs, and child's characteristics to a lesser extent. Some paternal characteristics were also retained, such as parenting confidence and the presence and position of the father in the household. The list of all assessed determinants and their bivariate associations with adoption of family-led MUAC can be found in the **Addendum.**

The multivariate regression analysis assessed the joint influence of the candidate determinants, identified by the bivariate analysis, on the adoption of family-led MUAC (**Figure 5**). We first highlight determinants of adoption common in both countries. Firstly, maternal probable depression was associated with a 6 pp (p<0.10) and 10 pp (p<0.01) higher adoption in Chad and Mali, respectively. Besides maternal depression, the Edinburgh postnatal depression score also assesses caregiver's anxiety. More concerned caregivers are more likely to check on their child more often, including measuring their child's MUAC. Secondly, exposure to program services is positively associated with adoption. In Chad, having received a home visit by a CCG member in the past month and screening by other actors had a direct positive influence on adoption of family MUAC by 14 pp (p<0.01) and 6 pp (p<0.05), respectively. In Mali, having received SQ-LNS in the past month was associated with a 9 pp (p<0.05) higher adoption. Thirdly, adoption of family-led MUAC was found lower when the child was with SAM (-14 pp, p<0.01) in Chad and marginally lower when a child suffered from wasting (-5pp, p<0.10) in Mali. Finally, time available to the caregiver may be positively associated with the adoption of family-led MUAC. In Chad, caregivers who have access to help for their activities may have had more time available to measure their child's MUAC (4 pp, p<0.05). In Mali, caregivers having attended one or more meetings to organize field work or meetings of saving groups were less likely to measure their child's MUAC (-17 pp, p<0.01).

The determinant analysis also found some conflicting or country-specific results. In Chad, screening was negatively associated with implementing recommended WASH and nutrition practices, such as disposing of a handwashing station with soap (5 pp, p<0.10), having initiated early breastfeeding (-6 pp, p<0.05) and mothers having consumed more food groups (higher dietary diversity) in the last 24 hours (-1 pp per additional food group, p<0.01). Conversely, children who received the recommended minimal meal frequency (MMF) were significantly more likely to be screened by family-led MUAC (24pp, p<0.01). Children with a higher height-for-age z-score were also slightly more likely to be screened by the household (2pp more per unit of HAZ-score). In Mali, adoption of family-led MUAC was mainly associated with caregiver's overall knowledge on breastfeeding, complementary foods, child health, WASH and screening and wasting treatment services (0.72 pp per unit score on a total of 36; p<0.01), caregivers having attended school (6.4 pp; p<0.01) and better WASH practices, namely the use of improved water treatment technologies in the household (11 pp; p<0.05) and, though marginally associated, disposing of a hand washing station with soap (9.2 pp; p<0.10). Furthermore, in Mali, there was a marginally better adoption in households belonging to the highest wealth tercile (3 pp, p<0.10).

Chad

HH has soap at handwashing station	-4.8
Mother has probable depression (≥10)	6.0
Mother's number of food groups	1.5**
Mother can have external support with problems	3.5**
Child had an early initiation of breastfeeding	-6.2*
Child has minimal meal frequency	24**
Child is severly wasted (WHZ<-3 or edema)	-14**
Child's height-for-age z-score	2.1*
HH received a home visit by VGS	14**
Child screened by a non-HH member	6.1*

Mali

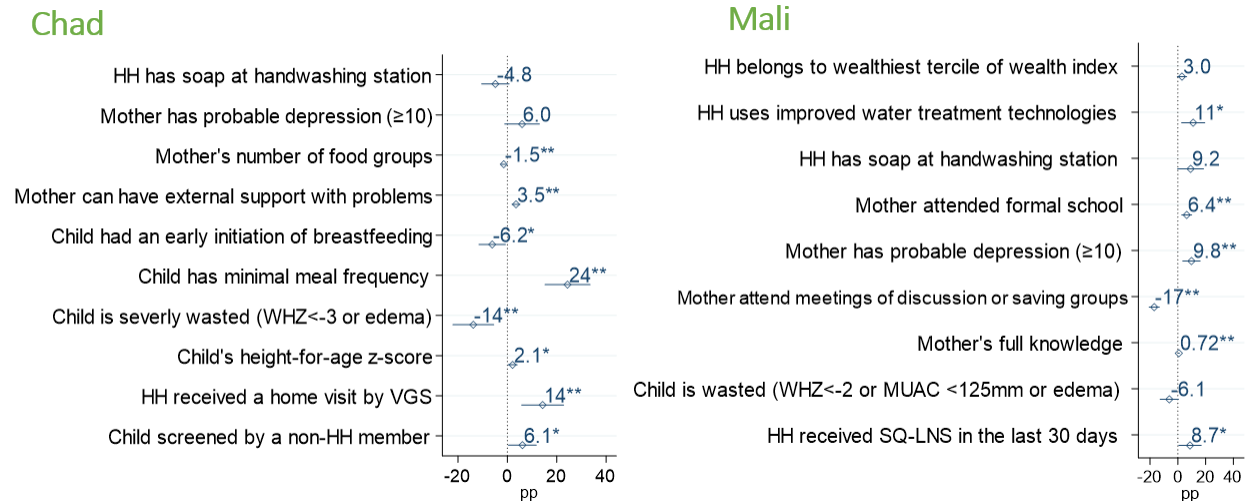|	
HH belongs to wealthiest tercile of wealth index	3.0
HH uses improved water treatment technologies	11*
HH has soap at handwashing station	9.2
Mother attended formal school	6.4**
Mother has probable depression (≥10)	9.8**
Mother attend meetings of discussion or saving groups	-17**
Mother's full knowledge	0.72**
Child is wasted (WHZ<-2 or MUAC <125mm or edema)	6.1
HH received SQ-LNS in the last 30 days	8.7*

Figure 5: Associations between household-, caregiver-, father-, child-, and service-level determinants and the adoption of the family-led MUAC approach in the subsample of households belonging to the IRAM intervention group owning a MUAC tape per month of follow-up (n=1,419 household-months for Chad; n=2,359 household-months for Mali). Estimates and 95% intervals were obtained from linear probability mixed-effects models with robust estimation of the standard errors and random effects at child level. The mean adoption of monthly family-led MUAC was 27% in the Chad and 41% in the Mali sample. No stars means a P-value between 0.05 and 0.10; *P<0.05; ** P<0.01.

Implementation

The implementation dimension refers to the fidelity to protocol of an intervention and allows to assess how consistently the intervention was delivered. In our context, we focused this dimension on the household level being the key actor implementing the family-led MUAC approach. More specifically, we determine whether household members performed frequent, accurate, and precise MUAC measurements. Furthermore, we assessed if the result (indicated by the color) of the family-led MUAC screening was correctly interpreted.

In both countries, around 50% of caregivers who measured their child's MUAC in the past month indicated measuring it once a week as recommended during the training delivered by NASGs and CCGs. In Mali, caregivers (or other household members frequently taking the child's MUAC) were asked to take the MUAC of their child in the presence of the study team. Thereafter, a study anthropometrist repeated the measurement. The numeric outcomes from both measurements were converted into the colors red, yellow, and green to represent the SAM, MAM, and non-wasted diagnosis, respectively (**Figure 6**). In Chad, we found excellent correspondence of 90% in the SAM subgroup, with more modest correspondence of 66% in the MAM subgroup. In Mali, we found very good correspondence of 73% and 81% for the SAM and MAM subgroups, respectively. In both countries 98-99% of non-wasted children were correctly diagnosed by caregivers. Summarizing the results for the whole sample of children, we found that the degree of misclassification varied between 6 and 8%, which is very acceptable.
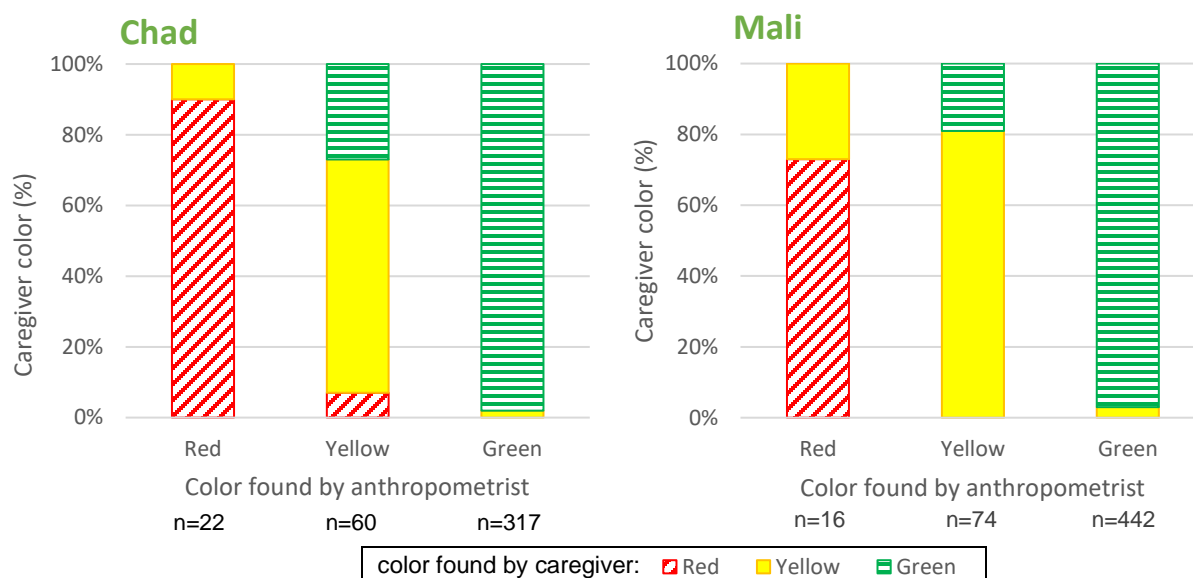
Figure 6: Stacked bar chart comparing the colored result of MUAC measurements by caregivers (indicated by colors) with those taken by study anthropometrists (indicated by bars). The colors red, yellow, and green represent SAM, MAM and non-wasted, respectively.

Caregiver knowledge of the meaning of the different colors on the MUAC tape was on average better in the IRAM intervention groups as compared to the control groups in both Chad and Mali (Table 3). Caregivers of the intervention groups were also more aware that a child needed to be registered in a MAM or SAM treatment program when the result of their MUAC screening was yellow or red. Caregivers disposing of a MUAC tape had better knowledge on screening of wasting compared to caregivers without MUAC tape, which suggests that guidance was provided during the distribution of the MUAC tapes.

Table 3: Caregivers' knowledge on the meaning of the colors of the MUAC tape and the expected action to be taken in case the MUAC tape indicates MAM or SAM in Chad and Mali

	All caregivers		Caregivers in households with a MUAC tape
	Comparison group	IRAM Intervention	IRAM Intervention
Chad	n= 740	n= 736	n=297
Knows meaning of green color on MUAC tape	598 (81%)	669 (91%) **	282 (95%) **
Knows meaning of yellow color on MUAC tape	550 (74%)	623 (85%) **	266 (90%) **
Knows what red color on MUAC tape mean	548 (74%)	635 (86%) **	275 (93%) **
Knows what to do when result is yellow	669 (90%)	714 (97%) **	293 (99%) **
Knows what to do when result is red	672 (91%)	716 (97%) **	295 (99%) **
Mali	n=1,094	n=1,263	n=726
Knows meaning of green color on MUAC tape	469 (43%)	708 (56%) **	498 (69%) ***
Knows meaning of yellow or red color on MUAC tape	422 (39%)	578 (46%) **	393 (54%) ***
Knows difference between yellow or red colors	357 (33%)	564 (45%) ***	401 (55%) ***
Knows what to do when result is yellow	459 (42%)	695 (55%) **	468 (64%) ***
Knows what to do when result is red	545 (50%)	800 (63%) **	538 (74%) ***

*Stars indicated the p-value of a clustered chi-square test comparing the knowledge between the IRAM intervention group (total and subgroup of households disposing of MUAC tapes) and the comparison group; ** and *** refer to p-values respectively below 0.05 and 0.01.*

Finally, we note that caregiver knowledge in both intervention and comparison groups in Chad was significantly better compared to that of caregivers in Mali. The higher knowledge levels in Chad might be explained by previous exposure of caregivers to a program on family-led MUAC implemented by the International Rescue Committee in the Mongo health district. In the study area in Mali, family-led MUAC was introduced for the first time.

Reach

The Reach dimension of the RE-AIM framework refers to the proportion of children screened by the family-led MUAC approach. In Chad, where the program started in June 2021, reach levels of family-led MUAC were lower than in Mali and remained below 20% throughout the study (**Figure 7**). In Mali, the proportion of children screened by family-led MUAC in the intervention group increased steadily throughout the study, albeit never reaching more than 30% of the sample of children.
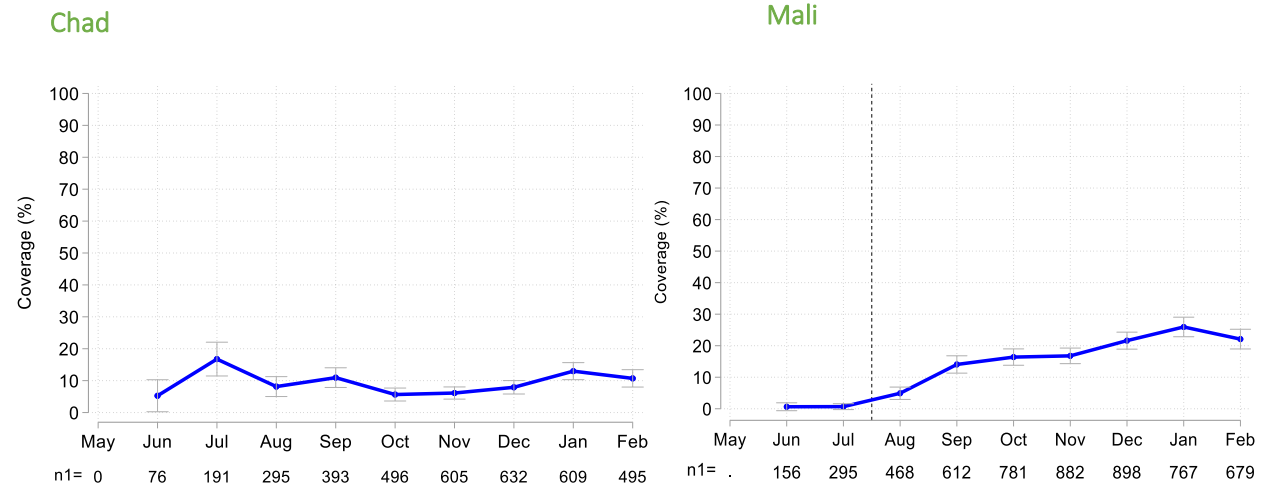

Figure 7: Reach of family-led MUAC in the IRAM intervention group in Chad and Mali by month. n1 represent the sample sizes per month. The vertical dashed line in the right panel indicates the start of the program in in Mali.

Because family-led MUAC was introduced as a complementary screening approach to the existing screening of wasting by community actors and health staff, it is of interest to quantify its marginal contribution to the total screening coverage. Our data suggest that in our study samples from Chad and Mali, the contribution of the family-led MUAC to the overall screening coverage was quite low. Most screening was exclusively done by actors outside of the household representing 26% and 37% of all children in Chad and Mali, respectively (**Figure 8**). In 6% and 10% of the total sample, children were screened by both family-led MUAC and by other actors within a same month, in Chad and Mali respectively. Conversely, only 3% of children in both countries were screened by family-led MUAC only. One important reason was that, as mentioned under the section on adoption, on average only 35% and 40% of households possessed a MUAC tape in Chad and Mali respectively. However, even after correcting for tape possession, the added value of family-led MUAC remained below expectation. In the subgroup of MAM and SAM children total screening coverage was higher as compared to the total sample of children. However, the low level of complementarity of family-led MUAC was also evident in this subgroup in both countries.
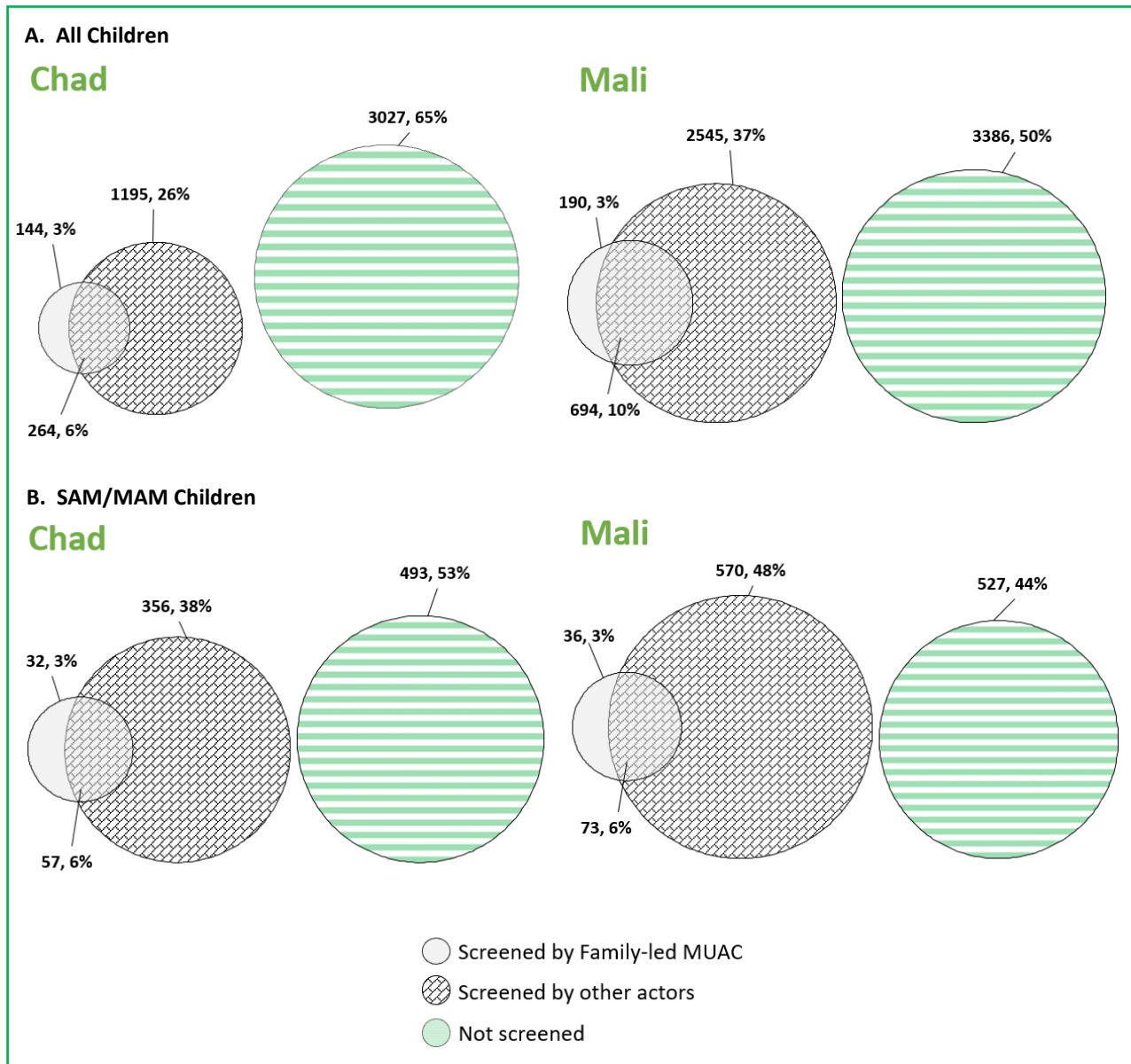
Figure 8: Number and proportion of children screened by different actors in Chad and Mali in the intervention group in total group of children (panel A) and the subgroup of SAM/MAM children (panel B).

Effectiveness

To evaluate the effectiveness dimension is to measure the impact of an intervention or initiative on the outcomes of interest. As the family-led MUAC approach aimed at improving early detection of wasting among wasted children for their early referral to treatment, evaluating its effectiveness is done by assessing to which extent children newly admitted in SAM/MAM treatment programs were previously diagnosed and referred for treatment by the caregiver and other household members.

We asked caregivers what subsequent actions were undertaken when a yellow or red color was obtained by family-led MUAC screening. In 29% (Chad) and 44% (Mali) of such events, the caregiver declared that no action was undertaken. When asking why no action was taken, 31% (Chad) and 59% (Mali) of caregivers

reported as main reason that they were unsure about the behavior to adopt (data not shown). These findings are in contrast with the high levels of caregiver knowledge related to family-led MUAC screening and referral, especially in the case of Chad (Table 3). Nevertheless, some of the responses during the in-depth interviews illustrate this lack of comprehension.

"No, it (knowing the meaning of the colors on the MUAC tape) is really difficult for us, especially since we did not go to school. It requires to have been to school to be able to interpret it". [Caregiver – IRAM intervention group Chad]

"There are three colors, but I do not know which one is showing, [I don't know] which one is acute malnutrition, because when they (NASGs) measure the arm circumference of the child, I do not look" [Caregiver – IRAM intervention group Mali].

The second most cited reason was that caregivers preferred to wait to see how their child would evolve (19% in both countries). Others reasons provided during the in-depth interviews were fear for the costs related to referral and treatment services, poverty, refusal of the spouse (for reasons including those related to a bad fate of recurrence of illness in the child that is linked to the consultation, field work) or spouses who do not support the mothers attending the treatment consultation, unawareness/negligence of the consequences related to malnutrition, ignorance, high workload (field labor or domestic work of the mother).

"If a child is referred to the health center, the person in charge [health staff] would have asked the women for money and this is what stops the women from going to the health center" [CCG member - Chad]

"If it's the preharvest or harvest period, going to tell your husband that the health agents have given you a paper to bring the child to the health center, can result in him telling you that you cannot leave the field work to go to the health center; he is the head of the household and if he says that you cannot go, this prevents some mothers" [NASG member - Mali]

In 40% (Chad) and 56% (Mali) of cases the caregiver indicated that she would seek help from the community health worker, health center or the NASG/CCG groups to enroll their child into MAM or SAM OTP. In Chad, 21% of caregivers cited that they continued to monitor their child progress by repeating MUAC measurements more often. In both countries, 14% of caregivers preferred to auto-resolve the child's wasting or to use the preventive supplements (SQ-LNS or CSB++) handed out by the program to treat their child's wasting.

Table 4: Actions taken by caregiver or family members after family-led MUAC screening identified a MAM or SAM episode in Chad and Mali

	Chad	Mali
	n=99	n= 72
No action taken	29 (29%)	32 (44%)
Child brought to health center/ CHW/NASG or CCG member (Self-referral)	53 (54%)	29 (40%)
Improved child's nutrition or increased ration of SQ-LNS/CSB	14 (14%)	10 (14%)
Measured MUAC more frequently	21(21%)	1 (1.4%)
Asked advice to family, friends, neighbors	1(1.0%)	0 (0.0%)

Another way of evaluating the effectiveness of family-led MUAC is to assess the proportion of self-referrals (by family-led MUAC) amongst MAM or SAM treatment admissions (**Table 5**). In most cases (46-60%), the initial case-identification and referral of MAM and SAM, in both comparison and intervention groups, was done solely by a non-household actor such as CCG, NASG volunteers or health staff. Family-led MUAC's unique contribution to admissions was very limited ranging from 2.9% in Mali to 4.1% in Chad. Concomitant case-identification and referral between family-led MUAC and other actors varied between 4% in the IRAM intervention group in Mali to 9% in the IRAM intervention group in Chad.

Table 5: Source of identification and referral of MAM and SAM cases admitted to treatment services.

	Chad		Mali	
	Comparison group	IRAM Intervention	Comparison group	IRAM Intervention
	n=213	n=194	n= 255	n=245
Self-referral only	0 (0%)	8 (4.1%) **	0 (0%)	7 (2.9%) *
Referral by a non-household actor only	127 (60%)	97 (50%)	117 (46%)	125 (51%)
Both self-referral and referral by non-household actor	9 (4.0%)	17 (9.0%)	1 (0.39%)	10 (4.0%) *
Referral by study enumerator only¥	9 (4.2%)	12 (6.2%)	94 (37%)	68 (27%) *
Unknown source of referral according to caregiver	68 (32%)	65 (34%)	43 (17%)	42 (17%)

¥ *In Mali, study teams referred both MAM and SAM cases to treatment services during the monthly home visits when taking anthropometric measures during their monthly home visits. In Chad, the same was done but only referring SAM children. This difference explains the higher proportion of referrals by study teams in Mali as compared to Chad. Stars indicated the p-value of a clustered chi-square test. * and ** refer to p-values respectively below 0.05 and 0.01.*

Maintenance

In both countries, barriers leading to limited adoption and reach of family-led MUAC need to be addressed and resolved before the maintenance dimension can be assessed. Nevertheless, we explore what necessary conditions are required to ensure family-led MUAC can be made sustainable.

In both countries, the maintenance of the family-led MUAC approach will depend largely on the capacity of NASG and CCG to effectively organize regular contacts with caregivers and household members. The study findings however suggest that NASG and CCG volunteers under the IRAM setup are not a suitable platform to introduce and maintain family-led MUAC. Because of the incompatibility between the time these volunteers can make available for the project and the proposed workload, the program had to accept that monthly home visits were not feasible unless a suitable compensation was offered to the volunteer groups. The project teams therefore decided to focus the delivery of the intervention more on the model of monthly village gatherings with, consequently, significantly poorer outcomes. In view of the suboptimal results obtained for family-led MUAC by this project, there is little to recommend on the dimension of maintenance beyond the need of financial support to provide households with MUAC tapes, and of actors, such as NASGs or CCGs, who can provide training and coaching to families and monitor adoption, implementation, and action when children are diagnosed as having MAM or SAM by FL-MUAC. Two elements that were proposed by community-leaders and CCG/NASG members to support maintenance during the in-depth interviews were more community-ownership of the intervention and the necessity of technical and financial support.

V.   Discussion

We conducted an in-depth evaluation of the programmatic implementation of the family-led MUAC approach in two different countries. The effectiveness of family-led MUAC in both countries was modest with 40-54% of all MAM or SAM cases identified by family-led MUAC leading to admission to treatment services. However, self-referrals by family-led MUAC only represented 3-4 % of the total admissions to treatment. Several RE-AIM dimensions help to interpret the reasons for the low effectiveness. First, the family-led MUAC approach was not adopted by CCG in Chad and NASG in Mali to the extent expected. The intended delivery platform for family-led MUAC were monthly home visits by CCG and NASG volunteers. However, from the first months of implementation, it became clear that the proposed workload of 30 home visits per volunteer was not feasible without any compensation. Many volunteers reported being unable to combine the program's tasks as a volunteer, with their main income-generating activities being predominantly agricultural labor. As such, the program proposed CCG and NASG to focus on monthly village gatherings as the main delivery platform. However, the dynamic and effectiveness of introducing family-led MUAC to larger groups (often 50-70 caregivers per session) turned out inferior to the individualized approach through home visits. We also observed that family-led MUAC was not always introduced during these monthly gatherings. The shift between delivery platforms can also explain why so few other household members (<10%) than the primary child caregivers were involved in family-led MUAC because typically, only caregivers and their children participated in the monthly sessions.

Though more households disposed of MUAC tapes throughout the program, less than half of the households disposing of MUAC tapes screened their children at least monthly. An important reason for caregivers not screening their children was being unsure on how to conduct the measurements, which suggests that the training of caregivers by CCG and NASG during the monthly gatherings needed to be improved.

The low degree of adoption of family-led MUAC led to a low reach of monthly screening by households of up to 10% in Chad and up to 25% in Mali. Furthermore, about two-thirds of children that family-led MUAC screened were also screened in the same month by other actors (predominantly CCG and NASG volunteers), suggesting limited complementarity of family-led MUAC to the existing screening platforms. The overlap between screening by family-led MUAC and screening by other actors can also be explained by the concomitant screening by caregivers and CCG or NASG volunteers as part of the family-led MUAC training. In different settings with less focus on active screening by CCG or NASG or where family-led MUAC is introduced by other actors than those who are already tasked to actively screen for wasting family-led MUAC would represent a higher unique contribution to the total screening coverage. On the other hand, caregivers with a MUAC tape available can screen their children more often, and thus detect wasting earlier, compared the monthly screening by CCG or NASG volunteers.

We also identified determinants that were associated with the adoption of family-led MUAC which aids in identifying subgroups of the population that may require additional support adopting family-led MUAC. The findings from IRAM Mali suggest that family-led MUAC was less practiced in more vulnerable households characterized by lower income, poor WASH practices and by more vulnerable caregivers with a lower level of caregiver school attendance and general knowledge of child nutrition and health, WASH and available wasting treatment services. Also, fewer contacts with NASG, as part of the IRAM program, was associated with less adoption. The latter was also supported by results from IRAM Chad that reported poorer adoption of family-led MUAC when households received fewer home visits or when their child was

less likely to be screened by other actors (a proxy of contact with the program). In Chad, however, a less clear determinant pattern emerged with better adoption in households with better off children in terms of linear growth or meal frequency contrasted with poorer adoption by caregivers with higher dietary diversity and better breastfeeding and WASH practices. Finally, we found that SAM children (in Chad) or children with wasting (in Mali) were less likely to be screened by family-led MUAC. We do not have a clear explanation for this finding other that some caregivers may have either preferred avoiding or were anxious about identifying their child with SAM or MAM.

Concerning implementation quality, we found that caregivers were able to measure their children's MUAC accurately but that the precision of the measurements can be further improved by strengthened formative supervision by CCG or NASG. Caregiver knowledge of family-led MUAC was very high in Chad and more moderate in Mali. This better knowledge by caregivers in Chad can be explained by a previous program that introduced family-led MUAC prior to IRAM.

VI.   Conclusion and recommendations

Based on the study findings, we propose the following recommendations to make family-led MUAC more effective:

- Develop strategies to make MUAC tapes available in a timely manner (from the age of 6 months) to all eligible households.
- Incorporate family-led MUAC theme in the national BCC curriculum for counseling the child caregivers. Existing BCC instruments, such as BCC flipcharts and registers, should include the family-led MUAC theme.
- Educate caregivers better about the risks of wasting, the importance of regular screening, and the referral to treatment services in case of MAM or SAM. This can be facilitated by creating stronger social support by developing strategies to actively involve the children's fathers in family-led MUAC. Reaching fathers requires awareness campaigns targeting activities primarily attended by men. These may include father support groups or male discussion groups. Such intervention will require strong support from community and religious leaders to champion family-led MUAC.
- Ensure continuing awareness by radio spots or scheduling family-led MUAC measurements during any contact with the (community-based) health system.
- Strengthen the ownership of family-led MAC by the community and the introduction of community-based monitoring of the activity.
- Pay more attention to the referral part after a case of wasting is detected by households and mitigation strategies to tackle possible barriers to enrolling children into existing treatment services. These aspects merit more emphasis during the training and the formative supervision of the program.
- Provide small financial compensations to encourage CCG and NASG volunteers to conduct more frequent home visits and to organize multiple monthly group sessions with smaller groups of caregivers to allow for a more individualized training of caregivers and other household members in family-led MUAC.

The IRAM studies in Mali and Chad have assessed the implementation of family-led MUAC, being one component of a multi-service intervention package, in Chad and Mali. Because of the COVID-19 crisis, the program was reduced to 7 and 9 months in Mali and Chad respectively. Such short program durations did not allow for a continuous learning process leading to the improvement of family-led MUAC over time and for a formative research phase to first assess the feasibility of home visits by CCG and NASG volunteers as the main delivery platform of family-led MUAC. Furthermore, family-led MUAC was implemented along CCG and NASG that were tasked with active screening children in their communities. Therefore, our results need to be interpreted in light of these context-specific elements. Based on the RE-AIM analysis, we conclude that family-led MUAC holds great potential to boost screening coverage of wasting but that its implementation to reach high levels of effectiveness needs carefully designed adoption and reach strategies, particularly in more vulnerable households. Furthermore, more effort should be invested in educating caregivers and other family members on the importance of enrolling children identified with MAM or SAM in treatment services to ensure that any higher reach of family-led MUAC translated into immediate referral and life-saving treatment.

VII.   References

1.   Bhutta ZA, Das JK, Rizvi A, Gaffey MF, Walker N, Horton S, et al. Evidence-based interventions for improvement of maternal and child nutrition: What can be done and at what cost? Lancet. 2013;382: 452–477.

2.   United Nations Children's Fund (UNICEF), World Health Organization (WHO), International Bank for Reconstruction and Development/The World Bank. Levels and trends in child malnutrition: UNICEF / WHO / World Bank Group Joint Child Malnutrition Estimates: Key findings of the 2023 edition. New York; 2023.

3.   Karlsson O, Kim R, Guerrero S, Hasman A, Subramanian S V. Child wasting before and after age two years: A cross-sectional study of 94 countries. eClinicalMedicine. 2022;46: 101353. doi:10.1016/j

4.   Unicef. Management of severe acute malnutrition in children: Working towards results at scale UNICEF Programme Guidance document. UNICEF Program Guid Doc. New York; 2015.

5.   Rogers E, Myatt M, Woodhead S, Guerrero S, Alvarez JL. Coverage of community-based management of severe acute malnutrition programmes in twenty-one countries, 2012-2013. PLoS One. 2015;10: e0128666.

6.   Nyirandutiye DH, Ag Iknane A, Fofana A, Brown KH. Screening for Acute Childhood Malnutrition during the National Nutrition Week in Mali Increases Treatment Referrals. Mock N, editor. PLoS One. 2011;6: e14818. doi:10.1371/journal.pone.0014818

7.   Blackwell N, Myatt M, Allafort-Duverger T, Balogoun A, Ibrahim A, Briend A. Mothers Understand And Can do it (MUAC): a comparison of mothers and community health workers determining mid-upper arm circumference in 103 children aged from 6 months to 5 years. Arch public Heal. 2015;73: 1–7.

8.   Puett C, Sadler K, Alderman H, Coates J, Fiedler JL, Myatt M. Cost-effectiveness of the community-based management of severe acute malnutrition by community health workers in southern Bangladesh. Health Policy Plan. 2013;28: 386–399.

9.   Glasgow RE, Vogt TM, Boles SM. Evaluating the public health impact of health promotion interventions: the RE-AIM framework. https://doi.org/102105/AJPH8991322. 2011;89: 1322–1327. doi:10.2105/AJPH.89.9.1322

10.   Kwan BM, McGinnes HL, Ory MG, Estabrooks PA, Waxmonsky JA, Glasgow RE. RE-AIM in the Real World: Use of the RE-AIM Framework for Program Planning and Evaluation in Clinical and Community Settings. Front Public Heal. 2019;7: 345. doi:10.3389/FPUBH.2019.00345/FULL

11.   RE-AIM.org. ASSESSMENT using RE-AIM and PRISM. [cited 23 Feb 2023]. Available: https://re-aim.org/assessments/#evaluate

Acknowledgements

About the authors

Loty Diop, Mariama Touré and Ampa D. Diatta are senior research analysts, Talla Fall is a research analyst, and Elodie Becquey is a senior research fellow, in the Food Nutrition Policy Department of IFPRI, based in Dakar, Senegal. Abdoulaye Sawadogo is a lecturer and researcher at University Joseph Ki-Zerbo, Ouagadougou, Burkina Faso and consultant and Moctar Ouedraogo is a demographer -sociologist at AfricSanté, Bobo-Dioulasso, Burkina Faso. Lieven Huybregts is a senior research fellow in the Food Nutrition Policy Department of the International Food Policy Research Institute (IFPRI), based in Washington, DC, USA.

Addendum

We conducted a determinant analysis to identify subgroups of households/caregivers that adopted family-led MUAC. For this purpose, we first assessed bivariate associations between indicators at the household-, caregiver-, and child-level and adoption of family-led MUAC and using logistic regression adjusted for clustering at the cluster and, in case of repeated measurements, at the child level. Candidate determinants were retained for multivariable analysis when the p-value of Wald test was ≤0.20. Then, multivariable linear probability mixed-effects regressions with robust estimation of the standard errors and random effects at the child level were run using these candidate determinants. The multivariable determinant analysis started from full regression models with all candidate determinants and applied a stepwise backward procedure to obtain an analytical model with determinants that had at least a p-value of 0.10 for the Wald test. The multivariable regression models were adjusted for clustering by health center catchment area (Mali) and village group (Chad), and sampling stratum (to account for the stratified clustered sampling design) and by child (in case of repeated measurements). For this analysis, we considered statistical significance at a critical p-value of 0.05 and marginal statistical significance at a p-value of 0.10.

Indicator	Description	Mali	Chad
HOUSEHOLD CHARACTERISTICS			
Distance between HH and HC, km	Linear distance between the household and health center calculated using GPS coordinates	green	red
Distance between HH and CHW, km	Linear distance between the household and CHW site calculated using GPS coordinates	red	red
Household Food Insecurity Access (HFIAS) Scale	Household Food Insecurity Access Scale	green	green
Household food secure	= 1 if household's HFIAS category is food insecure	red	red
Household mildly food insecure	=1 if household's HFIAS category is mildly food insecure	green	red
Household moderately food insecure	=1 if household's HFIAS category is moderately food insecure	green	red
Household severely food insecure	=1 if household's HFIAS category is severely food insecure	red	green
Household size	Total number of members of the household	red	red
Number of children under 5 years	Number of children under five years old in the household including the index child	red	red
Number of adults 15-64.9 years	Number of adults 15-64.9 years old in the household	green	green
Polygamous household	=1 if household head has more than one spouse	red	red
Tercile 1 (poorest)	=1 if the household belongs to first tercile of the wealth index[1]	red	green
Tercile 2	=1 if the household belongs to second tercile of the wealth index[1]	red	red
Tercile 3	=1 if the household belongs to third tercile of the wealth index[1]	green	green
Improved water treatment technologies used	=1 if household uses technologies to treat drinking water	green	red
Improved sanitation facility used	=1 if the type of toilet facility used is a pit latrine with slab	red	red

Indicator	Description	Mali	Chad
Handwashing station with soap available	=1 if a soap (bar, detergent, liquid) is observed at handwashing station	green	green
Improved primary water source used	=1 if the main drinking water source is a protected well, a pipe or the rain	red	red
HOUSEHOLD HEAD CHARACTERISTICS			
Household head is female	=1 if Household head is female	red	red
Adult 15-64.9y	=1 if household head's age is between 15-64.9 years old	red	red
Elderly 65y+	=1 if household head's age is over 65 years old	red	red

Indicator	Description	Mali	Chad
CAREGIVER CHARACTERISTICS			
Biological mother	= 1 if caregiver is biological mother of the child	green	green
Age	Caregivers' age in years	green	red
Wife of household head	=1 if the caregiver is married to the household head	red	red
Mother never attended school	=1 if the caregiver never attended formal school	green	green
Mother has an income generating activity	=1 if the caregiver had an income-generating activity at baseline (formal or informal)	green	red
Body Mass index (kg.m-2)	Caregiver's Body Mass Index	red	red
Underweight (BMI<18.5)	=1 if caregiver's Body Mass Index (BMI) is under 18.5, at least once during the critical period	red	red
Assisted delivery	=1 if caregiver had an assisted delivery during last pregnancy	green	red
Number of antenatal consultations during last pregnancy	Caregiver's number of antenatal consultations during last pregnancy	red	red
Probable depression (EPDS >=10)	= 1 if the Edinburgh Postnatal Depression Scale closest to start of episode is greater than ten	green	green
Probable depression (EPDS>=13)	= 1 if the Edinburgh Postnatal Depression Scale closest to start of episode is greater than thirteen	green	green
Parenting confidence	Karitane Parenting Confidence Scale of the caregiver	red	red
Total of MDDW food groups (10)	Total number of food groups consumed among ten defined	green	green
Minimum dietary diversity	=1 if the caregiver has consumed at least five out of ten defined food groups the previous day	red	red
Breastfeeding knowledge score	Knowledge score breastfeeding	red	red
Complementary feeding knowledge score	Knowledge score complementary feeding	red	red
Child's health knowledge score	Knowledge score child's health	red	red
Wasting screening knowledge score	Knowledge score wasting screening	green	red
SQ-LNS knowledge score	Knowledge score SQ-LNS	green	
MAS treatment product knowledge score	Knowledge score Plumpy Nut use	green	
MAM treatment product knowledge score	Knowledge score Plumpy Sup use	green	
Water potabilization knowledge score	Knowledge score water potabilization techniques		green

Indicator	Description	Mali	Chad
Child's psychomotor development knowledge score	Knowledge score on child's psychomotor development		Red
Full knowledge score	Full knowledge score compiling all sub-scores on PECIMA, health, breastfeeding,...	Green	Red
Gender: Tercile 1 (less empowered)	=1 if Household belongs to first tercile of gender index[2]	Red	Green
Gender: Tercile 2	=1 if Household belongs to second tercile of gender index[2]	Red	Red
Gender: Tercile 3	=1 if Household belongs to third tercile of gender index[2]	Red	Green
Freely decide over own money	=1 if caregiver can decide freely over own money	Green	Green
Number of occasions to meet and discuss with other women	Caregiver's number of occasions to meet and discuss with other women	Red	Green
Mother has someone who can help her	=1 if caregiver has someone who can help her in case of need	Green	Green
Meet other women about fieldwork or savings group	=1 if caregiver meet with other women to discuss fieldwork or savings groups	Green	
Mobility score	Score constructed from dichotomous variables stating whether the caregiver needs to seek permission to go to various kind of places (e.g., health center, market, family, etc.)	Red	Red
FATHER CHARACTERISTICS			
Age	Father's age in years	Red	Red
Parenting confidence	Karitane Parenting Confidence Scale of the father	Green	Green
Is household head	=1 if the father is household head	Green	Green
Father never attended school	=1 if the father never attended formal school	Red	Red
Father has an income generating activity	=1 if the father had an income-generating activity at baseline (formal or informal)	Red	Green
CHILD CHARACTERISTICS			
Male child	=1 if the child is male	Red	Red
Primigravidity	=1 if the child is the first-born child	Red	Red
Early initiation of breastfeeding	=1 if the child was breastfed within one hour of birth	Green	Green
Minimum dietary diversity	=1 if the breastfed 6-23 mo child received foods from ≥ 4 food groups during the previous day, at least once during the critical period	Green	Red
Minimum meal frequency	=1 if the 6-23 mo child received solid, semi-solid or soft foods the minimum number of times or more during the previous day (2 times for 6-8 mo breastfed, 3 times for 9-23 mo breastfed and 4 times for non-breastfed infants), at least once during the critical period[3]	Red	Green
Minimum acceptable diet	=1 if the breastfed 6-23 mo child had at least the minimum dietary diversity and the minimum meal frequency during the previous day and the non-breastfed 6-23 mo child received at least 2 milk feedings and had at least the minimum dietary diversity not including milk feeds and the minimum meal frequency during the previous day, at least once during the critical period (CP)[3]	Green	Red
Weight-for-length/height Z-score (WHZ)	Child's WHZ of the current month	Red	Red
Child wasting (WHZ<-2 or edema)	=1 if the child had a weight-for-length/height Z-score <-2 during the current month	Red	Red
Child severe Wasting (WHZ<-3 or edema)	=1 if the child had a weight-for-length/height Z-score <-3 during the current month	Red	Green

Indicator	Description	Mali	Chad
Mid-Upper Arm Circumference (MUAC)	Child's MUAC of the current month	🔴	🔴
Child GAM (WHZ<-2 or MUAC<125mm or edema)	=1 if the child had a WHZ <-2 or MUAC<125mm during the current month	🟢	🔴
Child SAM (WHZ<-3 or MUAC<115mm or edema)	=1 if the child had a WHZ <-3 or MUAC<115mm during the current month	🔴	🟢
Length/height-for-age Z-score (LAZ)	Child's LAZ of the current month	🟢	🟢
Prevalence of stunting (HAZ<-2)	=1 if the child had a HAZ <-2 during the current month	🟢	🟢
Weight-for-age Z-score	Child's WAZ of the current month	🟢	🔴
Child hemoglobin (g/dL)	Child's hemoglobin concentration in grams per deciliter	🔴	🔴
Anemia (Hb <11 g/dl)	=1 if the child had a hemoglobin concentration below <11g/dL	🔴	🔴
Severe anemia (Hb < 7 g/dl)	=1 if the child had a hemoglobin concentration below <7g/dL	🔴	🔴
Child suffers from GAM (MUAC<125mm) or edema	=1 if the child had a MUAC<125mm during the current month	🟢	🔴
Child recovering from GAM	=1 if the child is recovering from a GAM episode	🔴	🔴
Child recovering from SAM	=1 if the child is recovering from a SAM episode	🟢	🔴
SERVICES OFFERED BY IRAM INTERVENTION			
Number of VAD received	Number of home visits received by NASGs/CCGs during the IRAM intervention	🟢	🟢
New registration under treatment	=1 if the child is newly registered to a SAM/MAM treatment program	🟢	🟢
Child under treatment	=1 if the child is registered to a SAM/MAM treatment program	🔴	🟢
HH received SQ-LNS/CSB++ in the last 30 days for free	=1 if the household received SQ-LNS/CSB++ for child during the current month	🟢	🟢
Received home visit by GSAN in the last 30 days	=1 if the household received a home visit from NASG/CCG during the current month	🟢	🟢
Mother attended gathering in last 30 days	=1 if the caregiver attended a village gathering during the current month	🔴	
Received bottles of bleach in the last 30 days for free	=1 if the household received bottles of bleach from CCGs during the current month		🟢
Child screened in or outside the household	=1 if child was screened by other actors (other than family members) during the current month	🔴	🟢

For both countries and each outcome, the table reports in red the candidate determinants which did not pass the bivariate association test (p>0.20), and in green the indicators which passed this test and were considered for multivariable analysis.

[1]Score constructed using principal component analysis (pca) method from variables of household's characteristics (building material, source of lighting, etc.) and assets owned (TV, radio, bed, bicycle, etc.) and normalized to range (0-1).

[2]FAO, FHI 360. Minimum Dietary Diversity for Women: A Guide for Measurement [Internet]. Rome; 2016 [cited 2018 Oct 15]. Available from: www.fao.org/publications.

[3]Score constructed using principal component analysis (PCA) method from the variables of women empowerment covering question on the decision making, ability to purchase on own, contact with community, etc. normalized to range (0-1).

[4]Working Group on Infant and Young Child Feeding Indicators. Developing and Validating Simple Indicators of Dietary Quality and Energy Intake of Infants and Young Children in Developing Countries: Summary of findings from analysis of 10 data sets. 2006. Available from: https://www.fantaproject.org/sites/default/files/resources/IYCF_Datasets_Summary_2006.pdf