Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 1 June 2018 doi:10.20944/preprints201806.0017.v1

Peer-reviewed version available at *Int. J. Environ. Res. Public Health* **2018**, *15*, 1807; doi:10.3390/ijerph15091807

Title: Filling the gaps for community-based programs managing treatment and prevention of child malnutrition in non-emergency contexts: results from the Rainbow Project 2015-17 in Zambia

Author list:

Stefania Moramarco,[1,2*] Giulia Amerio,[2] Jean Kasengele Chipoma,[3] Karin Nielsen-Saines,[4] Leonardo Palombi,[1] Ersilia Buonomo[1]

Affiliations:

[1] Department of Biomedicine and Prevention, University of Rome Tor Vergata, via Montpellier, Rome 00133, Italy; e-mails: stefania.moramarco@gmail.com, ersilia.buonomo@uniroma2.it; leonardo.palombi@gmail.com

[2] Rainbow Project Association Pope John 23rd, 5656 Chinika Road, Ndola, Zambia ; e-mail: giulia.amerio@gmail.com

[3] Ndola District Health Office, 1307 Naidu Close, Ndola, Zambia; e-mails: jeankasengele@gmail.com

[4] Department of Pediatrics, David Geffen UCLA School of Medicine School of Medicine, Los Angeles, CA, 90095, USA

[4] Corresponding author: knielsen@mednet.ucla.edu; Tel.: +1-310-825-5235

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

Abstract

Background: Evaluation of nutrition programs is essential to guarantee the effectiveness of community-based management of acute malnutrition (CMAM).

Methods: The Rainbow Project Supplementary Feeding Programs (SFPs) in Zambia were evaluated between years 2015-17, following implementation of new recommendations based on previous evaluations (years 2012-14). Outcomes of the program were compared with International Standards and with those of 2012-14. Cox proportional risk regression analysis was performed to identify predictors of mortality and defaulting.

Results: Data for 900 under age 5 years malnourished children (48.8% male; mean age 19.7months ±9.9) were analyzed. Rainbow 2015-17 program outcomes met International Standards, for general malnutrition or stratified moderate acute malnutrition (MAM) and severe acute malnutrition (SAM). When comparing with 2012-14 outcomes, better performance was noted: mortality rates were reduced by half (5.6% vs 3.1%, p=0.01; for SAM: 12.4% vs 6.7%, p=0.006), with significant improvement in average weight gain and mean length of stay (p<0.001), and increased awareness of HIV status (+30%; p<0.001). HIV infection (5.5; 1.9-15.9), WAZ <-3 at baseline (4.6; 1.3-16.1) and kwashiorkor (3.5; 1.2-9.5) remained the major predictors of mortality.

Conclusion: The effectiveness of the Rainbow SFPs for child malnutrition treatment and prevention in Zambia has significantly improved after evaluation and implementation activities, with impressive outcomes which resulted in a 50% reduction in mortality.

Keywords: childhood malnutrition, community-based management of acute malnutrition- CMAM, moderate acute malnutrition –MAM, supplementary feeding programs -SFP, Zambia

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

Introduction

Childhood malnutrition remains a major public health problem throughout the developing world, being the underlying factor for nearly half of all yearly under-5 deaths from preventable causes [1]. It is estimated that more than 50 million children worldwide are affected by acute malnutrition, with 16 million having Severe Acute Malnutrition (SAM) and a further 33 million having Moderate Acute Malnutrition (MAM) [2]. Acute malnutrition, if untreated, is an attributable cause of death; 12.6% of the 6.9 million deaths worldwide among children under five years of age are due to acute malnutrition [3].

In Zambia malnutrition remains one of the most serious problems among children under five years of age. This condition is estimated to underlie 52% of all under-five deaths [4] (64 per 1000 live births in 2015) [5]. In 2015, the wasting prevalence in Zambia was 6.3% [6], which was off course from the World Health Assembly Nutrition target to "reduce and maintain childhood wasting to less than 5% by 2025" [7]. The picture of malnutrition has been exacerbated by high rates of HIV/AIDS (UNAIDS estimates that 85,000 children below 14 years of age were HIV infected in 2015 [8]) and by an exponential rise in tuberculosis (TB) over the last 3 decades, with children accounting for <10% of incident TB cases annually [9], more than 50% of whom are HIV co-infected [10,11].

The community-based management of acute malnutrition (CMAM) is unequivocally advocated as an effective program to address acute malnutrition for children aged 6 to 59 months, and is globally implemented in 55 countries. This approach, which provides services to local communities by decentralized treatment points within existing healthcare facilities is widely used across multiple humanitarian agencies both for SAM and MAM [12,13,14]. Although within CMAM, targeted SFPs are recognized as effective in the management of acute malnutrition, (treating MAM and preventing the deterioration into SAM) [15]), more evidence-based research evaluating the

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

effectiveness of SFPs into different scenarios is needed [16]. Key to the process is an approach that fine-tunes services according to local environments, with constant monitoring and evaluation activities to address areas of weakness and to support greater implementation accordingly, always sharing experience and knowledge at local level [13,17,18].

In Zambia, traditional CMAM is not widely available in the country and most areas are not covered by nutrition-specific interventions targeting acute malnutrition [19]. However, the Zambian Government still remains committed to scale-up provision of high impact services with special focus on maternal and child health [20]. Rainbow Project, under the Pope John 23rd Association, is the only locally well implemented program in the Ndola district with an integrated community-based approach combining MAM/SAM/ underweight treatment and prevention, operating through the SFPs since 1998. The current study describes the Rainbow SFPs performance from 2015 to 2017, following 2 years of evaluations and adjustments to the project.

Materials and methods

Setting

Rainbow Project operates 11 SFPs for Zambian malnourished children (ages 6-59 months) in the Ndola area (9 operating in urban areas -Twapia, Nkwazi, Kabushi, Kaloko, Kawama, Chifubu, Pamodzi Mackenzie - and 2 located in rural areas –Baluba, Chikumbi) with a particular focus on community mobilization and capacity building activities. All of the centers are run by leaders of small NGOs and Community-based Organizations (CBOs), and are coordinated by professionals of the Rainbow Office, in close network with health facilities, local clinics running Outpatient Therapeutic Programs (OTP), the Children's Hospital, the Ndola District Health Management Teams (DHMTs) and other local authorities. In CMAM programs, children with MAM are the main target of SFPs, while SAM rehabilitation is addressed by OTPs and/or Inpatient Care (IC) [21,22].

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

However, within the Zambian context, since the access to OTP/IC is restricted and/or the supply of ready-to-use therapeutic food (RUTF) is erratic in most areas in which Rainbow operates, children with SAM are enrolled in Rainbow SFPs, after referral to OTP/IC as a best practice. This choice has been made for ethical and humanitarian reasons, in order to facilitate the access of children/families most in need to nutritional supplementation, health education and all the other activities that are part of the Rainbow approach. Children who are underweight are enrolled in the program with the viewpoint that optimizing healthy child growth and improving nutritional status can have an impact on reducing and preventing rates of wasting [23,24]. Therefore, Rainbow SFPs provide an effective integrated approach for child malnutrition management, combining treatment and prevention of MAM/SAM/and underweight.

Rainbow SFPs activities

Rainbow SFPs protocol include both nutrition-specific or direct interventions (growth monitoring and supplementary food) and nutrition-sensitive or indirect interventions (nutritional counseling, health skills for guardians and child health promotion) [25]. Nutrition-specific activities (anthropometric assessment, on-site feeding, cooking demonstrations, food handouts: local food - maize flour, groundnuts, sugar, oil and fortified blended flour - high energy protein supplement/HEPS), coupled by nutrition-sensitive interventions (nutritional counseling and health education) are performed on a weekly basis. All community volunteers/operators are appropriately trained and constantly updated in Infant and Young Child Feeding (IYCF) practices promoted by the Zambian Government.

Supporting HIV voluntary counseling and testing (VCT) and active HIV case-finding are also part of SFP routine activities. Personnel are trained in confidentiality issues (e.g., counseling in the context of prevention of mother-to-child transmission PMTCT). Home visits performed by

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

community volunteers during nutritional rehabilitation are necessary to encourage good adherence to treatment and to tackle determinants of malnutrition at the household level.

Aim of the present study

The aim of the current study was to assess SFP outcomes and to evaluate program performance (Rainbow 2015-17), comparing the program to International Standards and the previous program results (Rainbow 2012-14). The first study of SFPs outcomes (Rainbow 2012-14) was conducted to evaluate program performance. During this review major challenges were identified and changes implemented accordingly. For the following two years more effort was put into staff training (most especially on HIV counseling and testing, nutritional counseling), and a new food schedule was implemented, with high energy protein supplement/HEPS redoubled (1000 g/weekly per child providing a daily ration of 150 g) [26]. Nutritional counseling was integrated as a routine activity of the SFPs, with pilot study results discussed elsewhere [27].

Study population and data collection

Data on Zambian malnourished children followed from July 2015 to April 2017 in the Rainbow Project SFPs around the Ndola area were analyzed using a community-based retrospective observational cohort study design. General pediatric information and socio-demographic characteristics, health and nutritional parameters were entered in a register edited *ad hoc* for the project by professionals of the Rainbow office. General information included date of birth, age, gender, and siblings. Socio-demographic data recorded included family history (parents' marital status, relationship and age of the guardian), and housing information (area of stay, address, household conditions). Health information included disability, medical complications and/or illness, enrollment in OTP, and HIV status. The latter (HIV status), was ascertained from the prevention mother-to child transmission (PMTCT) section of the child under-five card released from the

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

primary health care facilities of the Zambia Health Ministry. A color code was assigned to sensitive information (such as HIV status). Nutritional parameters included anthropometric measurement (weight, MUAC, edema). Data were registered after verbal consent of caregivers and in full respect of confidentiality, then collected from different sites and entered in a database with the removal of personal identifiers.

Anthropometric assessment and malnutrition classification

Malnourished children enrolled in Rainbow SFPs were recruited through community outreach or referred from local health facilities. The anthropometric assessment consisted in measuring weight, Mid-Upper Arm Circumference (MUAC), and checking for bilateral pitting edema. Children were assessed without clothes or footwear; weight (in kilograms) was measured using a mechanical baby scale graduated by 0.1 kg increments (salter 235). MUAC (in centimeters) was measured using a simple colored plastic strip (standardized UNICEF tape). Bilateral pitting edema was checked by applying gentle thumb pressure on the dorsum of the feet and assessing for residual depression; edema was detected as different grades.

Children were admitted to SFPs by using a two-priority criteria system of enrollment: first priority was given to acute malnutrition (SAM or MAM) and second priority to underweight status. Definition of SAM (MUAC ≤11.5 cm, and/or edema) and MAM (MUAC >11.5 and ≤12.5) was made according to the WHO/UNICEF criteria [28] and the Integrating Management of Acute Malnutrition (IMAM) guidelines of the Zambian Ministry of Health [29] for children aged 6 to 59 months. As recently indicated in the updated WHO guidelines, in order to achieve early community identification of malnourished children, Rainbow community volunteers measured the MUAC and examined children for pitting edema, reserving the assessment of weight for height and weight for

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

length (WHZ/WLZ) within primary health care facilities and hospitals [30]. Underweight was defined as a weight-for-age z-score (WAZ) <-2 [31].

If a child qualified at the same time for different criteria, the enrollment in SFPs was made considering the most severe condition of malnutrition. All children with MAM without health complications were enrolled directly, while children with MAM with health complications were first referred to the nearest health facility for medical care. If the child was found to have SAM without medical complications (either marasmus or kwashiorkor grade 1 and 2) he/she was primarily enrolled in OTP following best practice guidelines [29]. Simultaneously those children were enrolled in SFPs for ethical reasons, as previously reported. If the health staff identified a child as having SAM with medical complications, he/she was referred to the Arthur Davidson Children's Hospital for IC and then returned to Rainbow SFPs when discharged from the IC. All children stayed in the program until SFP discharge criteria were met: for two consecutive weeks MUAC should be > 12.5 cm, edema absent, or 15% weight gain had to be considered if underweight was the admission criteria.

Program outcomes and performance indicators

Standard outcomes were defined as recovery rate, death rate, and default rate. Recovered/cured was defined as an individual who met the discharge criteria. Defaulter was defined as a child lost to follow up for three consecutive weeks. A child was classified as "defaulter" when he/she dropped out of the study due to refusal or it was not possible to locate the child and make a home assessment. Death was registered when occurring during the time the patient was enrolled in the program. Early mortality and defaulting (within 15 days from enrollment) were excluded because they might not be directly attributable to the performance of the SFPs. Individuals who did not complete their rehabilitation because they moved to another area were considered transferred; this

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

outcome was not included in the performance evaluation because of the current absence of published targets. Length of stay and weight gain were considered additional indicators for targeted SFPs. Mean length of stay expressed the average time of stay for recovered children; mean weight gain expressed the average number of grams gained per kg per day among children who were cured. For humanitarian and ethical reasons, nutritional treatment was provided until children reached the recovery goals (treat-to-goal), so none were categorized as non-cured/non-responder (defined as cases that did not reach discharge criteria after a pre-defined length of time). Program outcomes were compared with exit categories for targeted SFPs from Sphere Project (recovery, death, and defaulter rate) and UNHCR guidelines (mean length of stay, and average weight gain). The Sphere Standards are the typical criteria used for assessing the effectiveness of SFP [32]. UNHCR guidelines are intended as a practical guide to design, implement, monitor, and evaluate selective feeding programs in emergency situations [23]. In addition, outcomes of Rainbow 2015-17 were compared with those previously published in 2012-14, in order to evaluate the impact of adjustments on the program performance.

Statistical analysis

Data were extracted from the Rainbow database and analyzed using SPSS software system 21.0 (IBM, Somers, NY, USA). Weight-for-age z-scores (WAZ) and MUAC-for-age z-scores (ZMUAC) were calculated using the WHO Anthro Software (Version 3.2.2, January 2011, WHO, Geneva, Switzerland) [33]. Descriptive data and variables measured were presented as means with standard deviations (SD). The Odds ratios 95% Confidence Intervals (OR; 95% CI), between age and acute malnutrition, SAM and length of stay, were calculated. Descriptive analysis was performed for the entire study population to estimate the proportion of children who recovered, died, and defaulted during the intervention phase. Rainbow 2015-17 outcomes were compared with those of Rainbow 2012-14, with student t-test for assessing the statistical significance of differences between

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

continuous variables and Z-test for independent proportions. For recovered children differences between means of anthropometric parameters from baseline to discharge were tested with the student t-test. Univariate and multivariate Cox regressions were performed to identify the main predictors of mortality and defaulting (hazard ratio: HR, 95% CI). Because there were multiple independent variables, a stepwise forward regression approach was used.

Results

Data on 1264 malnourished Zambian children (6-59 months) who were seen between July 2015 and April 2017 were extracted from the database. Children still on rehabilitation at the moment of the study were excluded from the analysis. Formally transferred, early mortality and early defaulting episodes (occurred within 2 weeks from admission) were not included. Eleven cases were excluded from the analysis because their records either had incomplete or missing baseline information. The overall sample analyzed therefore totaled 900 children, all with accurate and complete information relevant to measuring the outcome of the intervention (Figure 1). All children came from low socio-economic households. Main characteristics of enrolled children (sex, age, parental status - orphan of one parent, orphan of both parents, single parent - breastfeeding status, birth category/twin), comorbidity, and nutritional status recorded at baseline are reported in Table 1.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 1 June 2018 doi:10.20944/preprints201806.0017.v1

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

Figure1. Study flowchart.

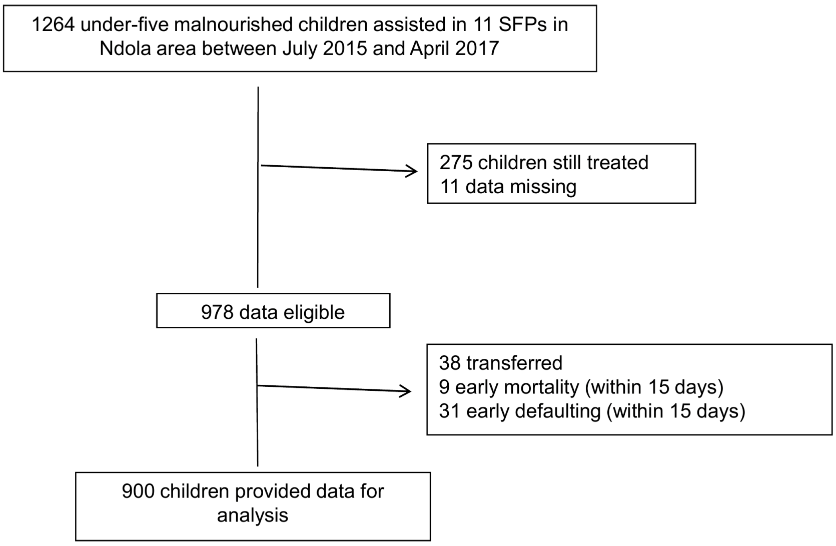


Table 1. Socio-demographic, health and nutritional characteristics of children at baseline.

Variables	Value
Male, n. (%)	439 (48.8)
Age in months, mean ± SD	19.7 ± 9.9
<18 months of age	452 (50.2)
Rural area, n. (%)	139 (15.4)
Parental status, n. (%)	
Orphans of one parent	32 (3.6)
Orphans of both parents	15 (1.7)
Single guardian	238 (26.4)
Disability, n. (%)	23 (2.6)
Twin, n. (%)	42 (4.7)
Caregiver's age, mean ± SD [min-max]	28.4 ± 9.2 [15-69]
Referred from, n. (%)	
Hospital	23 (2.6)
Local health facility	186 (20.7)
Community	691 (76.7)
HIV status, n. (%)	
Infected	25 (2.8)
Uninfected	541 (60.1)
Status unknown	334 (37.1)
Non-breastfed children, n. (%)	564 (62.7)
Months of age, mean ± SD	14.9 ± 6.9
Admission criteria: MAM, n. (%)	242 (26.9)

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 1 June 2018 doi:10.20944/preprints201806.0017.v1

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

<18 months of age	145 (59.9)
Admission criteria: SAM, n. (%)	346 (38.4)
<18 months of age	207 (59.8)
Admission criteria: Underweight, n. (%)	312 (34.7)
<18 months of age	100 (32.1)
Presence of oedema, n. (%)	184 (20.4)
Relapses of malnutrition event, n. (%)	129 (14.3)
Weight (kg), mean ± SD	7.6 ± 1.5
WAZ, mean ± SD	-3.1 ± 0.9
MUAC (cm), mean ± SD	12.2 ± 1
ZMUAC, mean ± SD	-2.4 ± 1
Health problems, n. (%)	429 (47.7)
Fever	75 (8.3)
Diarrhea	118 (13.1)
Lack of appetite	124 (13.8)
Cough/Sneezing	99 (11)
Malaria	4 (0.4)
Others	9 (1.1)

The cohort median age was 19.7 months ±9.9 SD. Almost half of the sample was represented by males (48.8%). At the time of admission, 26.9% of children were affected by MAM, 38.4% were affected by SAM (respectively 20.4% with kwashiorkor- presence of bilateral pitting edema- and 18% with marasmus), and 34.7% were admitted because of underweight status. The youngest children (<18 months of age) were more likely to be affected by general acute malnutrition (OR 3.2, CI: 2.4-4.2), with more than 90% of children with kwashiorkor having less than 29 months of age.

The mean weight at baseline was 7.6 kg ±1.5 SD; the mean MUAC was 12.2 cm ± 1 SD; the mean WAZ was -3.1± 0.9 SD, the mean ZMUAC was -2.4 ±1 SD. More than 14% of children suffered relapses of malnutrition, defined as a new episode of malnutrition after previous discharge from SFPs. A total of 47.7% of mothers/caregivers reported children experiencing health problems at the moment of enrollment; specifically, 8.3% had fever, 13.1% had diarrhea, 13.8% had lack of appetite, 11% had cough, 0.4% had confirmed malaria, and 1.1% had other unspecified conditions. No physical examinations were performed, but all those cases were referred to the nearest local

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 1 June 2018 doi:10.20944/preprints201806.0017.v1

Peer-reviewed version available at *Int. J. Environ. Res. Public Health* **2018**, *15*, 1807; doi:10.3390/ijerph15091807

health facility for immediate medical care. Moreover, at baseline 541 children were HIV uninfected (60.1%), and 25 (2.8%) were reported as HIV infected, with nearly half of them already on HAART (48%). HIV-positive children not receiving ARV treatment were referred to the ART clinic for assessment of ART eligibility. For the remaining 334 children (37.1%) the HIV status was unknown, with more than half of them (57.8%) being HIV exposed; guardians/mothers were therefore counseled and encouraged to go to the nearest health facility for an HIV test for both mother and child.

Program performance and anthropometric analysis for recovered children

In order to investigate performance, we evaluated Rainbow 2015-17 outcomes and compared results either with those of Rainbow 2012-14 and with International Sphere Standards/UNHCR indicators (Table 2).

Table 2. Rainbow 2012-14 vs. 2015-17 outcomes, and International Standards.

	Total			**MAM**			**SAM**			**International Standards (Sphere Project/UNHCR) [23,32]**	
Indicators	**Rainbow 2012-14 (n.858)**	**Rainbow 2015-17 (n.900)**	***P value***	**Rainbow 2012-14 (n.323)**	**Rainbow 2015-17 (n.242)**	***P value***	**Rainbow 2012-14 (n.241)**	**Rainbow 2015-17 (n.346)**	***P value***	**Acceptable**	**Alarming**
Recovered, n. (%)	709 (82.6)	771 (85.7)	0.08	278 (86.1)	219 (90.5)	0.1	177 (73.5)	284 (82.1)	***0.01***	>75%	<50%
Defaulters, n. (%)	101 (11.8)	101 (11.2)	0.72	36 (11.1)	17 (7)	0.09	34 (14.1)	41 (11.8)	0.42	<15%	>30%
Deaths, n. (%)	48 (5.6)	28 (3.1)	***0.01***	9 (2.8)	6 (2.5)	0.8	30 (12.4)	21 (6.1)	***0.006***	< 3% for SFPs <10% for TFPs	>10%
Mean length	19.3	16.6 ± 9.6	***<0.001***	19.3 ±	13.1 ± 7.4	***<0.001***	22 ±11.8	15.9 ± 9.6	***<0.001***	< 12 weeks for SFPs < 3-4 weeks for TFPs (IC	

Peer-reviewed version available at *Int. J. Environ. Res. Public Health* **2018**, *15*, 1807; doi:10.3390/ijerph15091807

of stay, weeks (SD)	±11.5			11.9						till full recovery) < 60 days for TFPs (IC and OTP combined)
Average weight gain, g/kg/day (SD)	1.7 ±1.2	2 ± 1.5	***<0.001***	1.7 ±1	1.9 ±1.2	***0.03***	2 ±1.3	2.4 ± 1.7	***0.007***	≥ 3g/kg/day for SFPs ≥ 8g/kg/day for TFPs (IC till full recovery) ≥ 4g/kg/day for TFPs (IC and OTP combined)

*TFPs =Therapeutic feeding programs

The three main core performance outcomes (recovery, death, and defaulter rate) met the Sphere Standards, either for general or when SAM and MAM outcomes were split: the overall recovery rate was 85.7% (90.5% for MAM and 82.1% for SAM); the global default rate was 11.2% (7% for MAM and 11.8% for SAM); the overall case-fatality rate was 3.1% (2.5% for MAM and 6.1% for SAM). General improvements in all rates of these main indicators were noted when compared with Rainbow 2012-14, with a statistically significant increase in recovery rate for SAM (p=0.01). Halving mortality rates was the main goal achieved since in the first evaluation it was above the targets; for total: 5.6% in Rainbow 2012-14 vs 3.1% in Rainbow 2015-17, p=0.01; for SAM: 12.4% Rainbow 2012-14 vs 6.7% in Rainbow 2015-17, p=0.006. The mean length of stay exceeded UNHCR targets, although for MAM the mean length of stay was exceeded only for one week the International standard (13.1 weeks ±7.4 SD). A longer period of recovery was needed by children with SAM (+4 weeks), with marasmatic children more likely to stay longer (OR 2.3, CI: 1.6–3.4), while children having kwashiorkor resolved earlier oedema (OR 0.4, CI: 0.3-0.6). As compared to Rainbow 2012-14, a reduction in the mean length of stay was noted either for total or for the two malnutrition groups (p<0.001).

Despite daily gains in mean grams per weight (2 g/kg/day ±1.5 SD), this measure was still below the international target of ≥ 3g/kg/day for SFPs. Nevertheless our findings are still in line with reviews of the literature (between 1 and 2 g/kg/day) when programs supplementing with corn/soy blended flour (CSB) were evaluated [34,35]. Children admitted with SAM had higher weight gains

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

then those with MAM. A statistically significant increase in the average weight gain was noted when outcomes were compared with that of Rainbow 2012-14, due to the new food schedule that allowed a reduction in the mean length of stay for recovered children, as proposed in the previous study.

Although international guidelines do not provide specific targets for children who are underweight, Rainbow SFPs have been effective in the nutritional rehabilitation of those children when comparing with standards Sphere (85.9% recovered, 13.8% defaulters, 0.3% deaths). Table 3 reports anthropometric assessment of recovered children (n=771). Comparison between the means of anthropometric parameters in recovered children at admission and discharge were assessed with paired sample Student's t-test. Our analysis showed significant improvements ($p < 0.001$): weight (7.6 kg ± 1.4 vs 8.9 kg ± 1.5; gain value of 1.4 ± 0.6); WAZ (-3 ± 0.9 vs -2.2 ± 0.8; gain value of 0.8 ±0.6); MUAC (12.3 ± 1 vs 13.6 ±0.8; gain value of 1.3 ±0.7) and ZMUAC (-2.3 ±0.9 vs -1.2 ± 0.6; gain value of 1.1 ±0.7).

Table 3. Changes in anthropometric parameters of recovered children.

	Admission	**Discharge**	**Gain value [95% CI]**	**Student t-test**	**p-value**
Weight, (kg) mean ±SD	7.6 ± 1.4	8.9 ± 1.5	1.4 ± 0.6 [1.3-1.4]	59.2	*<0.001*
WAZ, mean ±SD	-3 ± 0.9	-2.2 ± 0.8	0.8 ± 0.6 [0.7-0.8]	33.2	
MUAC, (cm) mean ±SD	12.3 ± 1	13.6 ± 0.8	1.3 ± 0.7 [1.2-1.3]	50.1	
ZMUAC, mean ±SD	-2.3 ± 0.9	-1.2 ± 0.6	1.1 ± 0.7 [1-1.1]	41.4	

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 1 June 2018 doi:10.20944/preprints201806.0017.v1

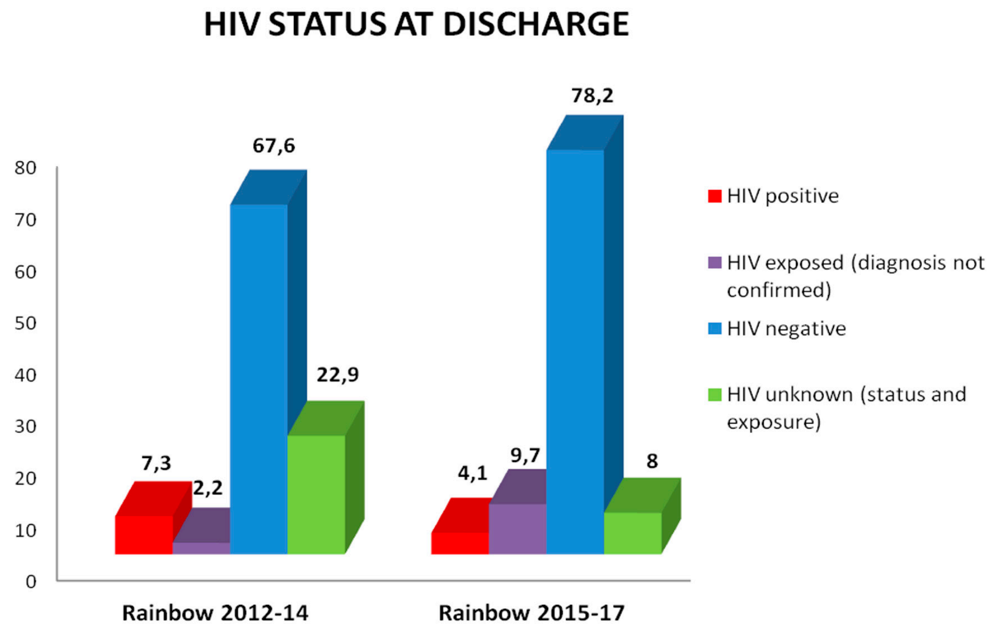
Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

HIV counseling and testing

Figure 2 presents a comparison between Rainbow 2012-14 and Rainbow 2015-17 at the time of patient discharge. The general number of children with HIV infection decreased over the years (7.3% vs 4.1%) and conversely the number of HIV negative children increased (67.6% vs 78.2%), reflecting the efforts of the Zambian government in promoting HIV PMTCT. In Rainbow 2015-17, 70% of HIV infected children were receiving antiretroviral treatment. The most incisive goal reached was the increased access to HIV diagnosis during the enrollment in SFPs. As compared to the nearly 49% of diagnoses made in Rainbow 2012-14, nearly 79% of new HIV diagnoses were made in Rainbow 2015-17 (30% greater; $p<0.001$). Among the 83 children who were HIV exposed but still without an HIV diagnosis (9.7%), nearly 65% were less than 18 months of age old, so presumably definitive test results were not yet available.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 1 June 2018 doi:10.20944/preprints201806.0017.v1
Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

Figure 2. HIV status at discharge: comparison between Rainbow 2012-14 and 2015-17.



	Rainbow 2012-14 ADMISSION	Rainbow 2012-14 DISCHARGE	Rainbow 2015-17 ADMISSION	Rainbow 2015-17 DISCHARGE
	TOTAL n.858		TOTAL n.900	
HIV UNKNOWN, n. (%)	381 (44.4)	197 (22.9)	334 (37.1)	72 (8)
HIV diagnosis within SFPs, n. (%)	184 (48.29)		262 (78.44)	

Predictors of mortality and defaulting

To identify the main predictors of mortality and defaulting we performed univariate and multivariate (forward stepwise model) Cox proportional risk regression analyses (HR, 95% CI). Baseline characteristics and nutritional response to rehabilitation were analyzed separately (Table 4). Baseline characteristics included socio-demographic conditions, HIV status, anthropometric and health status at admission. Nutritional rehabilitation included gains in anthropometric parameters.

HIV infection still remained the major predictor of mortality (HR 5.5; CI: 1.9-15.9), together with SAM defined as kwashiorkor (HR 3.5; CI: 1.2-9.5). Nutritional edema was associated with a high risk of mortality, and confirmed the importance of kwashiorkor as a public health problem, but was

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 1 June 2018 doi:10.20944/preprints201806.0017.v1

Peer-reviewed version available at *Int. J. Environ. Res. Public Health* **2018**, *15*, 1807; doi:10.3390/ijerph15091807

often not perceived as worrisome by guardians [36]. Severe underweight status at admission (WAZ<-3) also posed a greater risk of death (HR 4.6; CI: 1.3-16.1). This result was in line with the previous Rainbow study and highlighted the premise that prevention and management of underweight status, considered a second priority criteria of admission, should be recognized as an essential part of the program against childhood malnutrition [23,24]. Compared to Rainbow 2012-14, predictors of mortality were no longer noted to be risk factors for defaulting. We identified that living in the rural area (HR 2.3; CI: 1.3-4.2) and being orphan of any parent (HR 3.2; CI: 1.5-6.8) were the only two baseline variables associated with defaulting. Considering the nutritional response to treatment, poor gain in anthropometric parameters (WAZ gain, weight gain, ZMUAC gain) were independently associated either with case-fatality or defaulting. Specifically, when considering the multivariate Cox analysis, low weight gain and ZMUAC gain were more predictive of mortality, while poor WAZ gain and ZMUAC gain of defaulting.

Table 4. Predictors of mortality and defaulting. Cox proportion risk analysis.

		Predictors of mortality						Predictors of defaulting					
		Univariate analysis			Multivariate analysis			Univariate analysis			Multivariate analysis		
		HR	95% CI	*p value*	HR Exp (B)	95% CI	*p value*	HR	95% CI	*p value*	HR Exp (B)	95% CI	*p value*
Baseline characteristics	Age < 18 months	1.04	0.49-2.19	0.917	-	-	-	0.83	0.56-1.23	0.350	-	-	-
	Rural Area	0.24	0.03-1.78	0.164	-	-	-	**2.48**	**1.61-3.82**	***<0.001***	**2.31**	**1.27-4.21**	***0.006***
	Orphan	1.69	0.40-7.14	0.473	-	-	-	**2.41**	**1.26-4.64**	**0.008**	**3.22**	**1.52-6.81**	***0.002***
	HIV infection	**8.11**	**2.85-23.04**	***<0.001***	**5.53**	**1.92-15.94**	***0.002***	1.02	0.32-3.27	*0.968*	-	-	-
	WAZ< -3	**9.37**	**2.83-31.06**	***<0.001***	**4.57**	**1.30-16.11**	***0.018***	1.01	0.51-2.00	0.983	-	-	-
	ZMUAC <-2	**8.11**	**1.92-34.20**	***0.004***	-	-	-	1.50	0.99-2.30	0.062	-	-	-

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 1 June 2018 doi:10.20944/preprints201806.0017.v1

Peer-reviewed version available at *Int. J. Environ. Res. Public Health* **2018**, *15*, 1807; doi:10.3390/ijerph15091807

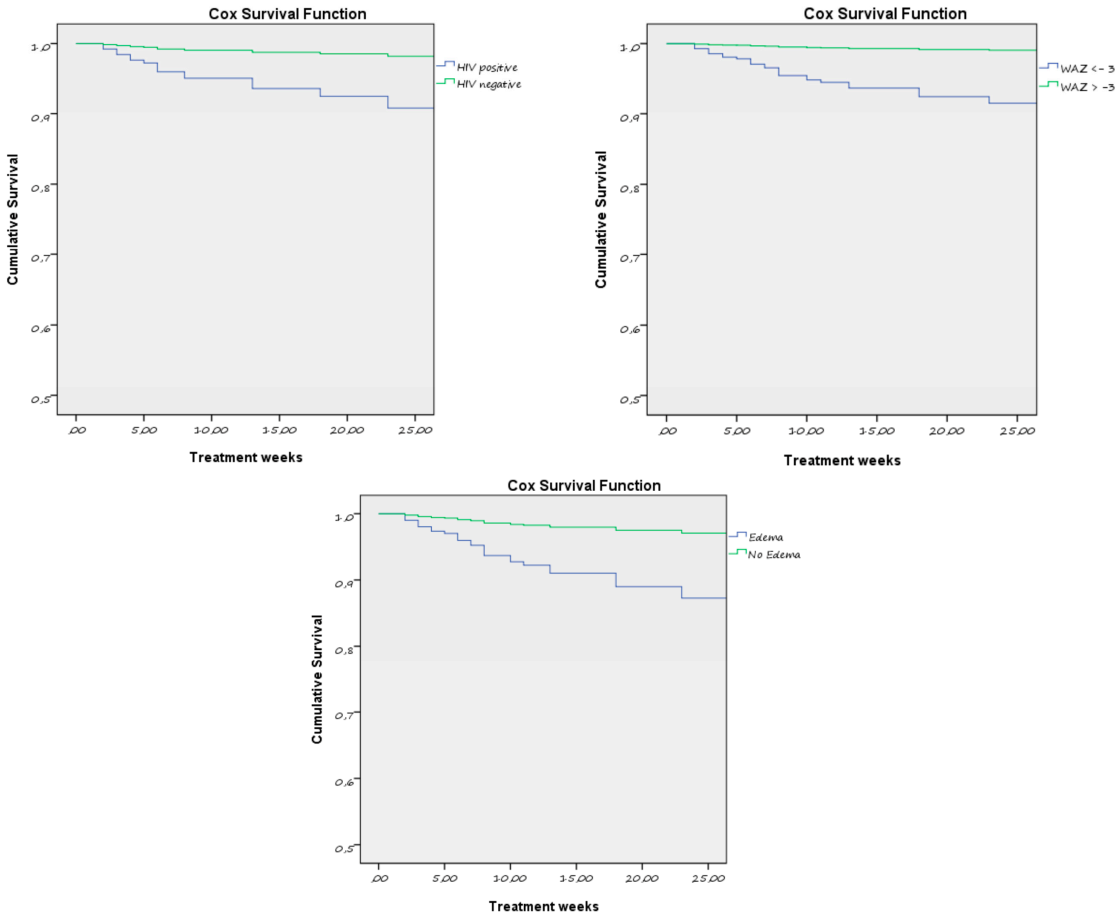
	Kwashiorkor / oedema	**4.59**	**2.14-9.85**	***<0.001***	**3.51**	**1.29-9.51**	***0.014***	1.10	0.65-1.86	0.724	-	-	-
	Health problems	1.75	0.82-3.73	0.149	-	-	-	1.34	0.91-1.99	0.140	-	-	-
Nutritional response	**Weight gain (g/kg/die)**	**0.42**	**0.34-0.51**	***<0.001***	**0.59**	**0.48-0.74**	***<0.001***	**0.57**	**0.49-0.65**	***<0.001***	-	-	-
	WAZ gain	**0.17**	**0.12-0.24**	***<0.001***	-	-	-	**0.29**	**0.23-0.38**	***<0.001***	**0.58**	**0.41-0.82**	***0.002***
	ZMUAC gain	**0.21**	**0.16-0.28**	***<0.001***	**0.35**	**0.24-0.51**	***<0.001***	**0.32**	**0.26-0.40**	***<0.001***	**0.44**	**0.33-0.59**	***<0.001***

Figure 3 shows the result of the Cox survival analysis (per outcome death) by HIV status, baseline WAZ and presence of edema.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 1 June 2018 doi:10.20944/preprints201806.0017.v1

Peer-reviewed version available at *Int. J. Environ. Res. Public Health* **2018**, *15*, 1807; doi:10.3390/ijerph15091807

Figure 3. Cox survival analysis. Outcome death by HIV status, WAZ <-3, presence of edema at baseline.



Discussion

The present analysis highlighted that well-trained and supervised community volunteers are capable of identifying and managing cases of uncomplicated malnutrition, providing accurate, reliable and trustable data [37]. These results are not easily demonstrable in community programs as discussed in field reports, where data collection and analyses are often not rigorously performed [13]. Recognizing that continuous technical assistance and support, staff training and routinely monitoring and evaluation are essential to enhance program effectiveness and guarantee high standards, a first evaluation of Rainbow SFPs was conducted between 2012-14, in which good programs outcomes were generally noticed, but some areas needing improvement were identified.

The main objective of the current study was to assess Rainbow SFPs performance between 2015 and 2017, after two years of implementation of changes for program improvement. When analyzing outcomes, performance indicators met the Sphere International Standards, either in general or when considering SAM and MAM separately, with statistically significant improvements compared to Rainbow 2012-14. Halving of mortality rates was the main observable goal (for total: 5.6% in Rainbow 2012-14 vs 3.1% in Rainbow 2015-17, p=0.01; for SAM: 12.4% Rainbow 2012-14 vs 6.7% in Rainbow 2015-17, p=0.006). The average weight gain significantly increased in Rainbow 2015-17, reaching the upper threshold of 2g/kg/day as reported in the scientific literature for programs supplementing with corn/soy blended flour (CSB) [34,35].

We believe that sharing food within the household could have been a potential explanation for poor weight gain, since it is a common cultural practice especially in food insecurity contexts [38]. The mean length of stay in the program for recovered children was significantly reduced as compared to Rainbow 2012-14 (6 weeks of treatment less for both MAM and SAM, p<0.001), despite this figure still exceeding the UNHCR targets, with a longer period needed for children with marasmus while edema resolved more rapidly. The better weight gain due to the new food schedule providing higher-quality food distribution coupled with individual nutritional counseling, allowed the reduction of the mean length of stay for recovered children, as proposed in the previous study. Our findings demonstrated outcomes similar to other studies evaluating community-based programs for moderate malnutrition despite lower weight gain [39,40], or in some cases with a better cure rate but higher mortality rates [41]. It was difficult to compare the length of stay with results from other field studies, since "non-cured/non-responder" was not an outcome of Rainbow SFPs, but nutritional assistance was ensured to all children until recovery occurred. Children admitted with lower MUAC had higher weight gains and longer lengths of stay, so that early detection and

 doi:10.20944/preprints201806.0017.v1

Peer-reviewed version available at *Int. J. Environ. Res. Public Health* **2018**, *15*, 1807; doi:10.3390/ijerph15091807

recruitment of acute malnutrition cases using MUAC could reduce lengths of stay and associated treatment costs [42].

The number of children who were HIV infected decreased over years and conversely the number of HIV negative children increased, reflecting the efforts of the Zambian government in promoting HIV PMTCT. This observation was in line with the country report which demonstrated a decline in HIV MTCT from 14.9% in 2013 to less than 9% in 2014 [43]. At the moment of data collection, the country adopted and then progressively implemented, WHO Option B+, recommending lifelong triple-combination ART for all confirmed HIV-infected children regardless of CD4 count and/or WHO clinical stage [44]. The significant reduction in children with unknown HIV status at the time of discharge reflected the large effort put into VCT for HIV for which Rainbow's community volunteers were strongly trained and their knowledge on HIV/AIDS and VCT was supported.

Despite the remarkable effort of community operators in increasing the diagnosis of HIV within the Rainbow 2015-17 program as compared to Rainbow 2012-14 (nearly 30% more diagnoses, $p<0.001$), the number of children who still remained with an unknown HIV status upon termination of the nutritional program underscores the stigma of HIV and fear of discrimination still existent in Zambia. In addition, the Cox proportional risk analysis showed that HIV infection still remained a major predictor of mortality [45]. Along with the risk to survival, it is widely recognized that children affected by HIV/AIDS are at serious risk of developmental delays, reported also for those exposed to HIV *in utero* but born uninfected, and for those whose parents are affected by HIV [46,47]. More research is needed to investigate these results within the Zambian context.

Low weight-for-age at baseline (<-3SD) and kwashiorkor diagnoses were other main predictors of mortality. The high prevalence of kwashiorkor found at admission (20.4%) was consistent with the

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 1 June 2018 doi:10.20944/preprints201806.0017.v1

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

proportion of SAM cases presented in the Zambia country report [36]. The poor gain in anthropometric parameters (WAZ gain, weight gain and ZMUAC gain) during nutritional rehabilitation was independently associated either with case-fatality or defaulting. Future research on growth velocity should be performed in order to define better indices for predictors of child mortality [48].

It is important to recognize that there is a best-practice algorithm for management of child malnutrition (such as OTP for SAM children), but when CMAM is not well-divulged and widely implemented, failure to act in different types of malnutrition may lead to a missed opportunity for lowering child mortality. Including children underweight in SFPs allowed for early optimization of nutritional status, with a positive impact on prevention of acute malnutrition [23,24]. These efforts may also assist in preventing long-term morbidity impacting quality of life, development, and economic prospects in adult life [49]. The Rainbow experience in the Zambian non-emergency setting supports the hypothesis that monitoring and evaluation activities of CMAM, tailored to local specific needs, improve sustainability and effectiveness of integrated models for prevention and treatment of childhood malnutrition [50]. Integrated programs, that promote general malnutrition prevention and also treatment, hold the potential to reduce the prevalence of acute malnutrition by reducing incidence and enhancing treatment effectiveness [16]. There is growing evidence that integrated programs provide a stronger impact on nutritional and health outcomes than either intervention alone [51,52]. Nutritional rehabilitation has not been considered a stand-alone intervention within CMAM: nutritional counseling, IYCF knowledge, HIV/AIDS counseling, testing and diagnosis, immunization sensitization and awareness, control of infections, TB prevention and screening, must be integrated in CMAM protocols, as these are critical primary care elements [53,54,55]. Integration of health and nutrition packages are successful in strengthening efficiency and sustainability of community-based programs which fight childhood malnutrition,

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

resulting in CMAM being effective not only in emergency contexts but also when routinely delivered in non-emergency settings. Therefore full collaboration and dialogue among different stakeholders dealing with malnutrition need to be constantly promoted and enhanced.

Study limitations include the lack of common standard protocols for evaluating the effectiveness of community-based programs delivered in non-emergency contexts, with Sphere indicators still being the main markers for assessment of CMAM performance. Conditions for delivering CMAM programs are not the same in non-emergency and emergency contexts, and for this reason, relying only on Sphere guidelines to measure program performance may not be comprehensive enough [56]. More research is needed to identify other field-based indicators which should be included in the evaluation of the effectiveness of CMAM, such as specific indicators for underweight and relapse malnutrition rates. In fact, we have identified a high proportion of relapses that need further investigations, in accordance recent literature [57].

Conclusion

The Rainbow SFPs integrated approach for MAM/SAM and underweight treatment and prevention is effective and sustainable for reduction of child mortality among Zambian under-5 malnourished children.

Consistent monitoring and evaluation with identification of critical areas and adjustments made accordingly, as well as continuous technical assistance and support, resulted in significant gains in the process and generated positive outcomes, with consequent enhancement of program performance. Our results emphasize the need for scaling-up CMAM within a multi-sectoral approach in order to better fight all forms of childhood malnutrition and tackle their determinants. This is especially relevant in food insecurity contexts where high burden of infectious diseases co-exist. Rainbow SFPs can act as an entry point providing child growth surveillance, nutrition and

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

health promotion, and facilitate access to HIV/TB treatment and care for Zambian children in non-emergency settings.

Acknowledgments

We acknowledge with gratitude all the children and their guardians assisted in SFPs during these years of work. We thank the Association Pope John the 23rd and all the operators and volunteers of NGOs/CBOs involved in the nutritional program for their tremendous job in the community. We thank Clarice Ciarlantini, Marta Don, Alessia Capuano, Emanuela Alzari who helped in data collection in the field and for merging data files used in these analyses. We are particularly grateful to Elisabetta Garruti and Gloria Gozza for project management, guidance and support. We would also like to thank all the Ndola District Health Office for their constant support and advice.

Authors' contributions

SM performed the statistical analysis and interpretation of the data, drafted and wrote the manuscript, made a substantial contribution to the local implementation. GA supervised the study at local level, contributed to the interpretation of the data, provided critical comment and revision of the manuscript. JKC reviewed the paper and provided critical comment, made a substantial contribution to the local organization. KNS reviewed and edited the manuscript and contributed critical comments. LP performed the statistical analysis, contributed to the data interpretation and provided critical comment and revision of the manuscript. EB supervised the study, performed the statistical analysis and the interpretation of the data, provided critical comment and revision of the manuscript. All authors red and approved the final manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 1 June 2018 doi:10.20944/preprints201806.0017.v1
Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

Abbreviations

AIDS: Acquired Immune Deficiency Syndrome

ART: Antiretroviral Therapy

ARV: Antiretroviral

CBOs: Community-based Organizations

CI: Confidence Interval

CMAM: Community-Management of Acute Malnutrition

CSB: Corn soya blended food

CTC: Community-based Therapeutic Care

DHMTs: District Health Management Teams

HAART: Highly active antiretroviral therapy

HEPS: High energy protein supplement

HIV: Human Immunodeficiency Virus

HR: Hazard Ratio

IC: Inpatient Care

IMAM: Integrated Management of Acute Malnutrition

IYCF: Infant and Young Child Feeding

MAM: Moderate Acute Malnutrition

MUAC: Mid-Upper Arm Circumference

NGOs: Non-Governmental Organizations

OR: Odds Ratio

OTP: Outpatient Therapeutic Care

PMTCT: Prevention Mother-to-Child Transmission

RUTF: Ready-to-use Therapeutic Food

SAM: Severe Acute Malnutrition

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

SD: Standards Deviation

SFP: Supplementary Feeding Programs

SPSS: Statistical packages for social sciences

TFP: Therapeutic Feeding Programs

TB: Tuberculosis

TDRC: Tropical Diseases Research Centre

UNHCR: United Nations High Commissioner for Refugees

UNICEF: United Nations International Children's Emergency Fund

VCT: Voluntary counseling and testing

WAZ: Weight-for-Age Z-score

WHO World Health Organization

WHZ: Weight-for-Height Z-score

WLZ: Weight-for-Length Z-score

ZMUAC: Mid-Upper Arm Circumference for Age Z-score

References

1. Blössner, M.; de Onis, M. Malnutrition: quantifying the health impact at national and local levels. Geneva: World Health Organization; 2005. WHO Environmental Burden of Disease Series, No. 12. Available from: http://apps.who.int/iris/bitstream/10665/43120/1/9241591870.pdf.
2. No Wasted Lives initiative: The State of Severe malnutrition website. Available from: http://www.severemalnutrition.org/en/home/Ge.
3. Black, R.E.; Victora, C.G.; Walker, S.P.; Bhutta, Z.A.; Christian, P.; de Onis, M.; et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet 2013; 382: 427–51. http://dx.doi.org/10.1016/ S0140-6736(13)60937-X.

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

4. Michelo, C.; Mugode R. Set criteria might have high potentials in the management of severely malnourished children in Zambia, evidence from an evaluation of an Outpatient Therapeutic Care Program (OTP) in selected communities in Lusaka urban, Zambia. Med. J. Zambia 2012; 39: 6–12. Available from: https://www.ajol.info/index.php/mjz/article/download/110592/100350.
5. World Health Statistics 2017: monitoring health for the SDGs, Sustainable Development Goals. Geneva: World Health Organization; 2017. Licence: CC BY-NC-SA 3.0 IGO. Available from: http://apps.who.int/iris/bitstream/10665/255336/1/9789241565486-eng.pdf?ua=1.
6. International Food Policy Research Institute. Global Nutrition Report 2016: From Promise to Impact: Ending Malnutrition by 2030. Washington, DC; 2016. Available from: http://dx.doi.org/10.2499/9780896295841.
7. World Health Organization. Global Nutrition Targets 2025: Policy Brief Series. 2014. Available from: http://www.who.int/nutrition/global-target-2025/en/.
8. UNAIDS. Country reports. Zambia HIV and AIDS estimates websites. Available from: http://www.unaids.org/en/regionscountries/countries/zambia.
9. MOH. National TB/Leprosy program 2016 TB notification data. Lusaka: Department of Public Health 2017.
10. Chabala, C.; Somwe, S.; Kapata, N.; Chongwe, G.; Jumbe-Marsden, E. Childhood tuberculosis at the main referral hospital in Lusaka, Zambia—A five year review of registered child TB cases. In: 43rd Union conference on Lung Health. vol. PC-661-15. Kuala Lumpur; 2012..
11. Munthali, T.; Chabala, C.; Chama, E.; Mugode, R.; Kapata, N.; Musonda, P.; et al. Tuberculosis caseload in children with severe acute malnutrition related with high hospital

 doi:10.20944/preprints201806.0017.v1

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

based mortality in Lusaka, Zambia. BMC Res Notes. 2017; 10: 206. doi:10.1186/s13104-017-2529-5. PubMed Central PMCID: PMC5468953; PubMed PMID: 28606173.

12. Hedwig, D.; Swindale, A.; Grant, F.; Navarro-Colorado, C. Review of Community-based Management of Acute Malnutrition (CMAM) in the Post-emergency Context: Synthesis of Lessons on Integration of CMAM into National Health Systems. Washington, DC; 2008. Available from: https://www.fantaproject.org/sites/default/files/resources/CMAM%20Review%20Synthesis%20Report_v2_0.pdf.
13. United Nations Children's Fund. Evaluation of Community Management of Acute Malnutrition (CMAM): Global Synthesis Report. New York; 2013. Available from: https://www.unicef.org/evaldatabase/files/Final_CMAM_synthesis_FINAL_VERSION_with_ExSum_translations.pdf.
14. Emergency Nutrition Network. Government experiences of scale-up of Community-based Management of Acute Malnutrition (CMAM) A synthesis of lessons. In: CMAM conference. 2012. Available from: http://files.ennonline.net/attachments/1374/cmam-conference-2012-synthesis.pdf.
15. UNHCR/WFP. Guidelines for Selective Feeding Programmes in Emergencies, 1999. Available from: http://www.who.int/nutrition/publications/en/selective_feeding_emergencies.pdf. Accessed 11 January 2018.
16. Huybregts, L.; Becquey, E.; Zongrone, A.; Le Port, A.; Khassanova, R.; Coulibaly, L.; et al. The impact of integrated prevention and treatment on child malnutrition and health: the PROMIS project, a randomized control trial in Burkina Faso and Mali. BMC Public Health. 2017; Mar 9;17(1):237. doi: 10.1186/s12889-017-4146-6. PubMed Central PMCID: PMC5343313; PubMed PMID: 28274214.

Peer-reviewed version available at *Int. J. Environ. Res. Public Health* **2018**, *15*, 1807; doi:10.3390/ijerph15091807

17. Collins, S.; Sadler, K.; Dent, N.; Khara, T.; Guerrero, S.; Myatt, M.; et al. Key issues in the success of community-based management of severe malnutrition. Food Nutr Bull. 2006; 27 Suppl 3: S49-82. doi: 10.1177/15648265060273S304. PubMed PMID: 17076213.
18. Dent, N.; Deconinck, H.; Golden, K.; Brown, R.; Walsh A. Information-sharing to improve learning about community-based management of acute malnutrition (CMAM) and its impact. Food Nutr Bull. 2014; 35:S86–90. doi: 10.1177/15648265140352S113. PubMed PMID:25069299.
19. Maleta, K.; Amadi, B. Community-based management of acute malnutrition (CMAM) in sub-Saharan Africa: Case studies from Ghana, Malawi, and Zambia. Food Nutr Bull. 2014 Jun;35 Suppl 2:S34-8. doi:10.1177/15648265140352S105. PubMed PMID: 25069291.
20. Ministry of National Development Planning. Seventh National Development Plan 2017-2021. Lusaka, Zambia; 2017. Available from: https://www.lusakatimes.com/wp-content/uploads/2017/06/Final-7NDP-07-06-17.pdf.
21. World Health Organization. Management of Severe Malnutrition: A Manual for Physicians and Other Senior Health Workers. Geneva; 1999. Available from: http://whqlibdoc.who.int/hq/1999/a57361.pdf.
22. Valid International. Community-Based Therapeutic Care (CTC): A Field Manual. 2006. Available from: http://www.concernusa.org/content/uploads/2015/08/ctc_manual_v1_oct06.pdf.
23. UNHCR/WFP. Guidelines for Selective Feeding: The Management of Malnutrition in Emergencies. January 2011. Available from: http://www.unhcr.org/4b7421fd20.pdf.
24. Black, R.E.; Laxminarayan, R.; Temmerman, M.; Walker, N.; Reproductive, Maternal, Newborn, and Child Health. Disease Control Priorities, third edition, volume 2. Washington, DC: World Bank; 2016. PubMed PMID: 27227235.

25. Moramarco, S.; Amerio, G.; Gozza Maradini, G.; Garuti, E. Rainbow project: A model to fight child malnutrition in Zambia. In: Harris J, Haddad L, Grütz SS, editors. Turning Rapid Growth into Meaningful Growth: Sustaining the Commitment to Nutrition in Zambia. Brighton, UK: IDS; 2014; 57–61. Available from: https://opendocs.ids.ac.uk/opendocs/bitstream/handle/123456789/4399/Zambia%20Special%20Collection%20pages%2069-73.pdf?sequence=1&isAllowed=y.

26. Moramarco, S.; Amerio, G.; Ciarlantini, C.; Kasengele Chipoma, J.; Kakungu Simpungwe, M.; Nielsen-Saines, K.; et al. Community-Based Management of Child Malnutrition in Zambia: HIV/AIDS Infection and Other Risk Factors on Child Survival. Int. J. Environ. Res. Public Health. 2016; 1; 13(7). doi: 10.3390/ijerph13070666. PubMed Central PMCID:PMC4962207, PubMed PMID:27376317

27. Moramarco, S.; Amerio, G:, Chafula Muyaba, L.; Bonvecchio, D.; Abramo, E.; Palombi, L.; et al. Nutritional counseling improves dietary diversity and feeding habits of Zambian malnourished children admitted in Rainbow nutritional programs. Biomedicine & Prevention; 2017.

28. World Health Organization, United Nations Children's Fund. Child Growth Standard and Identification of Severe Acute Malnutrition in Infant and Children. A Joint Statement; WHO: Geneva, Switzerland; 2009. Available from: http://apps.who.int/iris/bitstream/10665/44129/1/9789241598163_eng.pdf?ua=1.

29. Zambian Ministry of Health. DRAFT Integrated Management of Acute Malnutrition Zambia Guidelines; Zambian Ministry of Health: Lusaka, Zambia, 2012.

30. World Health Organization. Guideline: Updates on the Management of Severe Acute Malnutrition in Infants and Children. 2013. Available from: http://apps.who.int/iris/bitstream/10665/95584/1/9789241506328_eng.pdf?ua=1.

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

31. World Health Organization. WHO Child Growth Standards: Length/Height-for-Age, Weight-for-Age, Weight-for-Length, Weight-for-Height and Body Mass Index-for-age: Methods and Development. WHO: Geneva, Switzerland; 2006. Available from: http://www.who.int/childgrowth/standards/Technical_report.pdf.
32. The SPHERE Project. The Sphere Handbook: Humanitarian Charter and Minimum Standards in Disaster Response, 3rd ed.; The SPHERE Project: Geneva, Switzerland; 2011. Available from: https://www.unscn.org/uploads/web/news/2011-Sphere-Project-Handbook-Humanitarian-Charter-in-Humanitarian-Response.pdf.
33. WHO Anthro for personal computers, version 3.2.2, 2011: Software for assessing growth and development of the world's children. Geneva: WHO, 2010. Available from: http://www.who.int/childgrowth/software/en/.
34. Ashworth, A.; Ferguson, E. Dietary counseling in the management of moderate malnourishment in children. Food Nutr. Bull. 2009; 30: S405–33. doi:10.1177/15648265090303S304. PubMed PMID: 19998865.
35. Matilsky, D.K.; Maleta, K.; Castleman, T.; Manary, M.J. Supplementary Feeding with fortified spreads results in higher recovery rates than with a corn/soy blend in moderately wasted children. J Nutr. 2009; 139(4): 773-8. DOI:10.3945/jn.108.104018. PubMed Central PMCID: PMC3151028, PubMed PMID: 19225128.
36. Alvarez, J.L.; Dent, N.; Browne, L.; Myatt, M.; Briend, A. Putting Child Kwashiorkor on the map. In: CMAM Forum Technical brief. March 2016. Available from: http://files.ennonline.net/attachments/2485/Putting-Kwashiorkor-on-the-Map.pdf.
37. Alvarez Morán, J.L.; Alé, F.G.; Rogers, E.; Guerrero, S. Quality of care for treatment of uncomplicated severe acute malnutrition delivered by community health workers in a rural area of Mali. Matern Child Nutr. 2017. doi: 10.1111/mcn.12449. PubMed PMID: 28378463.

38. Akparibo, R.; Harris, J.; Blank, L.; Campbell, M.J.; Holdsworth, M. Severe acute malnutrition in children aged under 5 years can be successfully managed in a non-emergency routine community healthcare setting in Ghana. Matern Child Nutr. 2017. doi: 10.1111/mcn.12417. PubMed PMID: 28185414.

39. Somassé, Y.E.; Bahwere, P.; Laokri, S.; Elmoussaoui, N.; Donnen, P. Sustainability and scaling-up analysis of community-based management of acute malnutrition: Lessons learned from Burkina Faso. Food Nutr. Bull. 2013; 34: 338–48. doi: 10.1177/156482651303400306. PubMed PMID:24167914.

40. Ackatia-Armah, R.S.; McDonald, C.M.; Doumbia, S.; Erhardt, J.G.; Hamer, D.H.; Brown, K.H. 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 trial. Am. J. Clin. Nutr. 2015; 101: 632–45.doi: 10.3945/ajcn.113.069807. PubMed PMID:25733649.

41. Karakochuk, C.; Van den Briel, T.; Stephens, D.; Zlotkin, S. 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 trial. Am. J. Clin. Nutr. 2012; 96: 911–16. Doi: 10.3945/ajcn.111.029744. PubMed PMID:22952175.

42. Binns, P.J.; Dale, N.M.; Banda, T.; Banda, C.; Shaba, B.; Myatt, M. Safety and practicability of using mid-upper arm circumference as a discharge criterion in community based management of severe acute malnutrition in children aged 6 to 59 months programmes. Arch Public Health. 2016; 15;74:24. Doi: 10.1186/s13690-016-0136-x. PubMed Central PMCID:PMC4908708, PubMed PMID:27307989.

Peer-reviewed version available at *Int. J. Environ. Res. Public Health* **2018**, *15*, 1807; doi:10.3390/ijerph15091807

43. The National HIV/AIDS/STI/TB Council and Republic of Zambia. Zambia country report. Monitoring the Declaration of Commitment on HIV and AIDS and the Universal Access. Submitted to the United Nations General Assembly special session on HIV and AIDS. April 30th 2015. Available from: http://www.unaids.org/sites/default/files/country/documents/ZMB_narrative_report_2015.pdf.

44. Government of the Republic of Zambia Ministry of Health. Lifelong Antiretroviral Drugs (ARV's) for All HIV Positive Pregnant Women in Zambia. Policy Guidelines for Health Facilities in Zambia. 2013. https://www.medbox.org/zm-guidelines-hiv-tb/lifelong-antiretroviral-drugs-arvs-for-all-hiv-positive-pregnant-women-in-zambia/preview?.

45. Asafo-Agyei, S.B.; Antwi, S.; Nguah, S.B. HIV infection in severely malnourished children in Kumasi, Ghana: a cross-sectional prospective study. BMC Pediatr. 2013 Nov 9;13:181. Doi: 10.1186/1471-2431-13-181. PubMed Central PMCID:PMC 3828476, PubMed PMID: 24206638.

46. Sherr, L.; Mueller, J.; Varrall, R. A systematic review of cognitive development and child human immunodeficiency virus infection. Psychol Health Med. 2009; 14(4): 387–404. doi:10.1080/13548500903012897.

47. Buonomo, E.; Scarcella, P.; Tembo, D.; Giuliano, M.; Moramarco, S.; Palombi, L.; et al. Malnutrition decreases the odds of attaining motor milestones in HIV exposed children: Results from a paediatric DREAM cohort. Epidemiol. Prev. 2015; 39: 108–12. PubMed PMID:26499426.

48. O'Neill, S.M.; Fitzgerald, A.; Briend, A.; Van den Broeck, J. Child mortality as predicted by nutritional status and recent weight velocity in children under two in rural Africa. J Nutr. 2012; 142(3): 520-5.

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 1807; doi:10.3390/ijerph15091807

49. Kramer, C.V.; Allen, S. Malnutrition in developing countries. Paediatrics and Child Health. 2015; 25 (9): 422-27. Available from: http://dx.doi.org/10.1016/j.paed.2015.04.002.
50. Ruel, M.T.; Menon, P.; Habicht, J.P.; Loechl, C.; Bergeron, G.; Pelto, G.; et al. Age-based preventive targeting of food assistance and behavior change and communication for reduction of childhood undernutrition in Haiti: a cluster randomized trial. Lancet. 2008; 371:588–95. DOI:10.1016/S0140-6736(08)60271-8.
51. DiGirolamo, A.M.; Stansbery, P.; Lung'aho, M. Advantages and challenges of integration: opportunities for integrating early childhood development and nutrition programming. Ann N Y Acad Sci. 2014; 1308:46-53. Doi: 10.1111/nyas.12323.
52. Maust, A.; Koroma, A.S.; Abla, C.; Molokwu, N.; Ryan, K.N.; Singh, L.; et al. Severe and Moderate Acute Malnutrition Can Be Successfully Managed with an Integrated Protocol in Sierra Leone. J Nutr. 2015; 145(11): 2604-9. Doi: 10.3945/jn.115.214957.
53. Patel, D.; Matyanga, P.; Nyamundaya, T.; Chimedza, D.; Webb, K.; Engelsmann, B. Facilitating HIV testing, care and treatment for orphans and vulnerable children aged five years and younger through community-based early childhood development playcentres in rural Zimbabwe. J Int AIDS Soc. 2012;15 Suppl 2:17404. PubMed Central PMCID: PMC3499882, PubMed PMID:22789648.
54. Tomlinson, M.; Skeen, S.; Marlow, M.; Cluver, L.; Cooper, P.; Murray, L.; et al. Improving early childhood care and development, HIV-testing, treatment and support, and nutrition in Mokhotlong, Lesotho: study protocol for a cluster randomized controlled trial. Trials. 2016; 9; 17(1):538. doi:10.1186/s13063-016-1658-9.
55. Scarcella, P.; Moramarco, S.; Buonomo, E.; Nilesen-Saines, K.; Jere, H.; Guidotti, G.; et al. The impact of malaria on child growth: anthropometric outcomes in a pediatric HIV-

Peer-reviewed version available at *Int. J. Environ. Res. Public Health* **2018**, *15*, 1807; doi:10.3390/ijerph15091807

exposed cohort in Malawi. Biomedicine & Prevention; 2016; 1(53). doi:10.19252/000000035.

56. Emergency Nutrition Network. Government experiences of scale-up of Community-based Management of Acute Malnutrition (CMAM) A synthesis of lessons. In: CMAM conference. 2012. Available from: http://files.ennonline.net/attachments/1374/cmam-conference-2012-synthesis.pdf.

57. Somassè, Y.E.; Dramaix, M.; Bahwere, P.; Donnen, P. Relapses from acute malnutrition and related factors in a community-based management programme in Burkina Faso. Matern Child Nutr. 2016;12(4): 908-17. Doi: 10.1111/mcn.12197.