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Improving Nutrition and Child Development through Home Visitation in Rural Ghana

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Abstract

Introduction: Malnutrition is highly prevalent in low and middle-income countries (LMIC) around the world. Effective interventions are needed to correct malnutrition in young children so that normal growth and cognitive development are fostered, and fatalities are prevented.

Methods: This pilot study evaluated an integrated nutrition and developmental program for children ages 6 months to 6 years in rural Ghana. A team of community providers and health professionals identified the malnourished children. Nutrition interventions and developmental education were provided to these children and their caregivers. The interventions took place over a 9-month period in four rural villages through monthly to weekly home visits by nurses and a village assistant.

Results: Children who completed the intervention showed significant decreases in underweight status and developmental concerns with a trend towards decreases in wasting.

Conclusion: This pilot study demonstrates preliminary data on the benefit of a collaborative targeted, home intervention for young children with malnutrition in rural Ghana.

Keywords: Malnutrition; Ghana; home visitation; growth; development

Introduction

The mortality and morbidity associated with poor nutrition, diarrheal disease, malaria, and poverty continues in sub-Saharan Africa, even though it has been a recognized problem for decades [1]. Poor nutrition leads to a significantly higher risk of childhood illness, which can in turn have profound effects on the developing brain and can alter a child's trajectory for growth, health, and cognitive abilities [1]. Child undernutrition has been found to be strongly associated with less schooling, reduced economic productivity, shorter adult height, and for women, lower offspring birth weight [2-5]. Poor nutrition during early childhood directly and indirectly leads to permanent growth and neurodevelopmental deficits [6], which can reduce economic potential, and therefore self-sufficiency, for that individual.

Poor nutrition and malnutrition are significant public health problems for many children in rural Ghana, West Africa, where 28% of children under 5 years have stunted growth [1]. The first 1000 days of life are recognized as a critical period for brain development [1]. Interventions to promote health, wellness and positive nutrition in young children are essential to ensure optimal learning, minimize risk of developmental delays and promote school readiness [7]. Without intervention, there are permanent negative sequelae associated with malnutrition, malaria, anemia, parasites and diarrheal diseases. Effective, feasible and sustainable interventions to target malnutrition are especially needed in rural areas where poverty is high, and resources are low. As such, interventions can be life changing and lifesaving.

In 2007, an American and Ghanaian collaboration led to the start of an NGO (nongovernmental organization) called Project OKURASE whose mission is, while honoring Ghanaian arts and culture, collaborate with the village of Okurase, Ghana to develop sustainable, replicable solutions to life's biggest challenges and share lessons learned with other disadvantaged villages. Importantly, Okurase village, the site of the NGO, has the desire to serve as a teaching village to impart sustainable solutions to other villages. Project OKURASE structures its work around six objectives. health and nutrition, water, and sanitation, building the Nkabom Centre, cultural exchange, education and technology, economic self-sufficiency.

Critical to Project Okurase is for the village leaders to have input, approve and help to lead any projects that are undertaken. From 2008 to the present, through Project OKURASE and at the request of the village, Ghanaian health professionals, local residents, and international volunteers have jointly conducted a Village Health Outreach (VHO) in Okurase. The VHO, a weeklong free medical clinic with a free pharmacy has served over 15,000 people from Okurase and nearby villages to date. Oversight is by a Ghanaian medical director. Early on, at the VHO, it was noted that many children coming for health care had serious difficulties with malnutrition. This pilot study was born from the need seen at the VHO.

The current study sought to pilot solutions to address malnutrition in young children in Okurase and nearby villages. Okurase is located in the Upper West Akyem district of the eastern region of Ghana and has a population of approximately 3500 people, of which roughly half are children. It is a subsistence farming and drum-carving village. Malnutrition is a pervasive problem as food security is low, poverty is high, and the basic diet is carbohydrate heavy. Rates of malaria, anemia, and diarrheal diseases are high. In this context, the current project was implemented to facilitate healthy development in children through a nutrition program, employing regular monitoring with home-based nursing education. The overall objective was to determine if repeated education, using monthly home visits by nurses, and supplementing the diet of the targeted child would be feasible and would improve the growth and development of children recognized with malnutrition in Okurase and three other nearby rural villages within a 10-mile radius. Improving nutritional status, health, growth, developmental milestones, and adherence to the intervention were the variables of primary interest.

Methods

Ethics Approval

The Institutional Review Board (IRB) at the Medical University of South Carolina (USA), Ghana Health Service of the Ministry of Health, and UNICEF-Ghana Accra approved the study protocol. The informed consent was translated to the local Twi language.

Recruitment and Consent

Recruitment of families was conducted by the team through identification of children at the Village Health Outreach and walking through the village speaking with residents and teachers about the study. The inclusion criteria were:

a. Age range of 6 months to 6 years

b. Arm measurement of 13.5 centimeters or less

c. Capacity to meet at the NGO office for pre- and post-study measurement.

d. An agreement on the part of the family to be present for monthly at-home nursing measurements and monitoring and to recognize that the RUTF was medical food intended for the identified child. When an identified child met the inclusion criteria and the caregiver was interested, the informed consent was reviewed with them verbally. The caregiver either signed or thumb printed. The recruitment rate was 100%.

Data Collection and Measures

The research team from the United States had been involved in the VHO or had special expertise pertaining to the study. The research team in Ghana consisted of a local on-site project coordinator, a village-based assistant, and two male Ghanaian nurses. The nurses were professionally trained in nutrition education, basic health care disease prevention strategies (i.e. hand washing, proper use of mosquito nets), and methods for taking precise anthropometric measurements, medical and birth histories, and completed developmental interviews with the lead physician. All Ghanaian team members were trained in research ethics. The U.S. physician and nurses completed research measures with the caregiver and child at the beginning of the project and nine months later. Caregivers were provided with taxi fare to travel to the NGO office when needed. To thank them for their time related to research participation, caregivers were given culturally determined (e.g., tea, gari, coloring books) items. Research measures identified whether the children were experiencing malnutrition, under-nutrition, or stunting as established by the World Health Organization (WHO) [8-10]. Included were physical measurements, a detailed medical history, and developmental screening tools.

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Physical measures: Child anthropometry was measured following standard protocols [8] and measurements were plotted on WHO growth charts. Physical measurements were height and weight, head, and arm circumference as well as physical descriptions of hair color changes, pedal edema and wasting commonly associated with poor nutrition. Medical history included the approximate history and number of diarrheal episodes, infections, malaria episodes, anemia and history of illness and hospitalizations including birth history, allergies and family and social history and national health records. Each guardian or parent gave permission so that each child was photographed to document visible changes in skin and hair, arm circumference, the distension of the torso, and edema of the arms, legs, and face.

Developmental screening: The Parents Evaluation of Developmental Status-Developmental Milestones (PEDS-DM) was used to screen for developmental concerns. The PEDS-DM is a screening tool that measures developmental domains, including fine motor, gross motor, expressive language, receptive language, self-help, social-emotional skills and has been used in other countries (Glascoe, personal communication). This tool was completed by a combination of parent interview and clinician observation. Data gained from the PEDS-DM was then used to populate the Parents Evaluation of Developmental Status (PEDS) screening tool, which is a series of open-ended questions, eliciting caregiver concerns of the child for delayed expressive or receptive language, fine or gross motor functioning, behavior, social, self-help or learning problems categories.

Intervention

The intervention consisted of weekly home visits by the village-based assistant and monthly home visits by the nurses. The village-based assistant monitored families to encourage 2-3 meals a day, as well as use of daily supplements with packets of Ready-to-Use-Therapeutic-Food (RUTF) that had been donated by UNICEF. Adjustments on dosing with the RUTF medical food were made per age and size guidelines by an established formula. Families were instructed that this special RUTF medical food (also known as plumpy nut) was to be administered to the identified child. On a weekly basis, each family received clean and safe water, bread, and funding for fruits and vegetables for the duration of the study. The nurses, who met with families monthly, collected physical measurements of the child, engaged the caregiver in education on nutrition and safe practices such as hygiene, food preparation, proper hand washing, and drinking safe water plus malaria prevention. Interviews with caregivers were utilized to determine the frequency of diarrheal episodes, malaria, other illness and family or social stressors and how each child was tolerating the medical food supplement. Families were encouraged to use mosquito bed netting each night. Families received eight intervention visits by nurses.

Analytic Strategies

Descriptive characteristics are presented as means (ranges) for continuous or as percentages for categorical variables. Program impact analyses were conducted in a pre-and post-approach for key child outcome variables. Chi-square tests were used to assess differences in proportions between baseline and final visit. Nutrition status was assessed with anthropometry. Standardized z-scores based on World Health Organization reference charts [11-13] were calculated for weight, height, head circumference, body mass index (BMI). Indicators of nutrition status recorded included weight-for-age (WFA), weight-for-height (WFH), height-for-age (HFA), head circumference (HCZ), and BMI-for-age z-scores. Children were classified as stunted (HFA <-2 SD), underweight (WFA <-2SD), or wasted (WFH <-2SD), low head circumference (HCZ <-2SD), underweight by BMI (BMI <-2 SD).

In mother-child dyad analyses, we also assessed associations between maternal characteristics including nutritional status (height, weight, and BMI and leg length) and child growth measures in a subpopulation of biological mothers. Associations were quantified with repeated measures linear regression models that nested multiple measures from a child as random effects. Statistical significance was set at an a priori 2-tailed P value of <.05. We performed a post-hoc sample size power and calculation analysis in relation to our mother-child analyses. To detect a correlation of 0.25 between maternal vs. child anthropometry, at a power (1-β) of 80% and at alpha of 5% and adjustment for potential confounding factors, an N of 88 was required. Given that this is a small pilot study (n=25), trends as well as p-values are reported. For our analyses, we linked mother's anthropometry with repeated growth measures of their child during the entire duration of the study, and we realized an analytic sample size of 158. This is sufficient for descriptive bivariate and multivariate analysis, although a larger sample size could have increased precision around regression model point estimates.

Results

The overall objective of this pilot study was to determine if repeated nutrition education, using monthly home visits by nurses, and supplementing the diet of the targeted child through weekly village assistant visits would be feasible and would improve the growth and development of children recognized with malnutrition.

Study Participants

In this pilot study, 25 children with malnutrition (defined as mid-upper arm circumference <13.5cm), ages 7 to 58 months (60% male; mean baseline age 25.2 months), were identified. The children were from Okurase village (n=7, 28%) and three other

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nearby rural villages (Asuotwene n=14, 56%; Bediako n=2, 8%; Alafia No. 1 n=2, 8%). Despite challenges, 84% were retained (three moved; one died of kwashiorkor) over the intervention study. Thirty-two percent of children were not with biologic mothers and were with aunts, grandmothers, fathers or other relatives. Maternal and child characteristics are shown in Table 1. For the 15 available biological mothers, mean age was 26.9 years and average height was 162.2cm. Twenty (20%) percent of the mothers were classified underweight based on their BMI while 26.7% of them had low leg length (i.e. below 1st tertile of study mothers).

Child Physical and Developmental Measurements

Using age adjusted growth charts, the proportion of underweight children by BMI significantly decreased from 67% to 29%. Other measures were not significantly different but given that this is a small pilot, it is worth noting that the proportion of children identified as wasted, having low head circumference, underweight, and stunted, all showed reductions Figure 1.

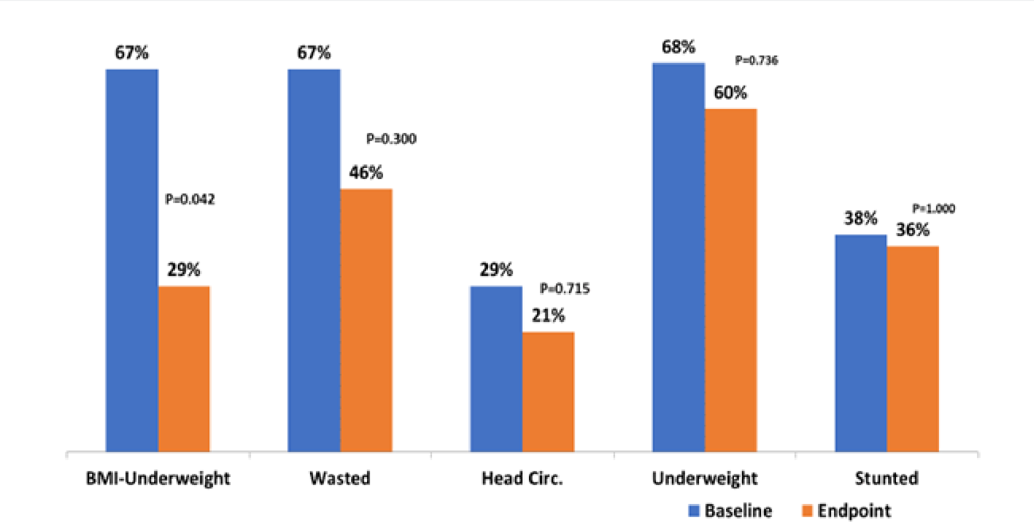

Figure 1: Indicators of low nutritional status at baseline and endpoint.

Table 1: Maternal and Child Descriptive Statistics.

Maternal Characteristics (n=15)	Mean (SD)
Age, y	*26.9 (8.8)*
Weight, kg	55.4 (10.4)
Height, cm	162.2 (4.8)
BMI, Kg/m^2	21.1 (3.7)
Leg length, cm	37.4 (4.7)
[1]BMI Categories	**Percent (%)**
% Underweight	20.0
% Normal	60.0
% Overweight	20.0
% Obese	0.0
Leg Length – Tertiles	**Percent (%)**
Maternal Lower length, 1st tertile	26.7
Child Characteristics (N=15) at Baseline	Estimate
Age, months (mean, min, max)	22.3 (7.0 - 40.0)
Sex Female %	40.0%
Weight, kg (Mean ± SD)	8.7 ± 1.6
Length/height, cm	77.9 ± 13.7
MUAC, cm (mean, min, max)	12.6, 11.5, 13.3
% living with biological mothers	68%

Underweight (<18.5); Normal (BMI: 18.5-24.9), Overweight (25-29.9), Obese > 30

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At baseline, using the PEDS-DM as a comprehensive interview and scoring on the PEDS short form, one or more expressive or receptive language, fine or gross motor, behavior, social, self-help or learning problems were reported for 84% of children and these dropped to 62% at study end. Figure 2 shows the reduction in developmental concerns for all metrics assessed. For example, gross motor development concerns reduced from 68% at baseline to 29% at endpoint.

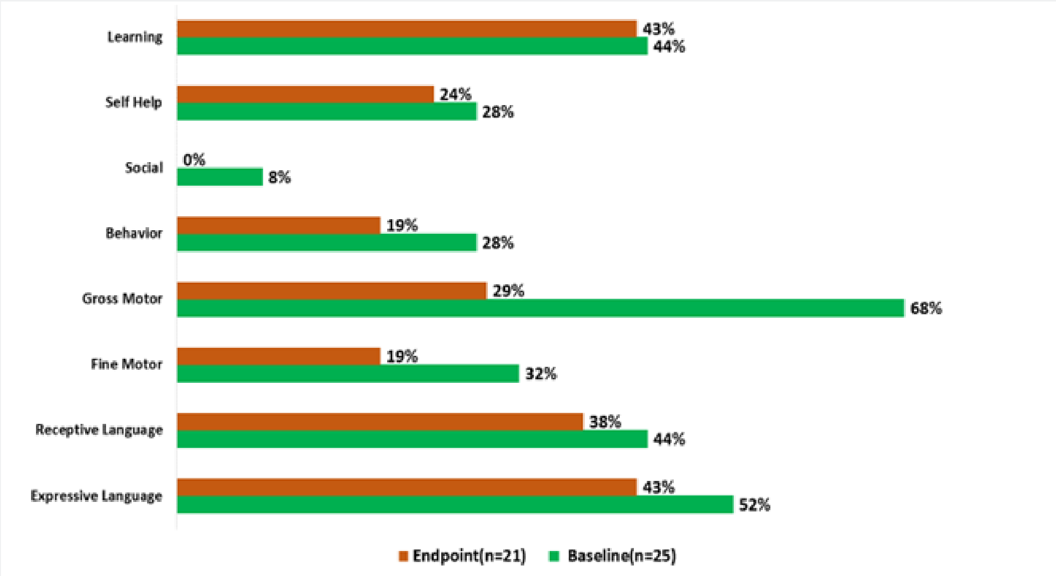

Figure 2: Distribution of developmental concerns baseline and endpoint.

Mother-Child Associations

Table 2: Associations (Prevalence Odds Ratios (95%CI) between Maternal Anthropometry and child stunting, underweight and wasting.

Maternal Nutrition Indicators	Child growth Indicators	
	Stunting (L/HAZ <-2SD)	
	Crude ¹POR (95CI %)	²Adjusted POR (95CI %)
BMI-Underweight	0.50 (0.3 – 0.7)	2.4 (0.3-22.6)
Height Lower Tertile	2.80 (1.5 –5.4)	4.29 (0.8 – 23.3)
Leg Lower Tertile	4.60 (2.0– 10.7)	10.9 (2.6– 46.3)
	Child Underweight (WAZ <-2SD)	
	Crude ¹POR (95CI %)	²Adjusted POR (95CI %)
BMI-Underweight	0.8 (0.4–1.6)	0.1(0.0 – 1.2)
Height Lower Tertile	1.1 (0.5–2.2)	0.4(0.1 – 2.0)
Leg Lower Tertile	2.0(0.8–4.9)	1.2(0.2 –7.4)
	Wasting (WFH <-2SD)	
	Crude ¹POR (95CI %)	²Adjusted POR (95CI %)
BMI-Underweight	0.8(0.5–1.4)	0.2(0.0 – 2.0)
Height Lower Tertile	0.6(0.4 –1.0)	0.2(0.1 –0.7)
Leg Lower Tertile	0.7(0.4–1.1)	0.3(0.1– 1.1)

All odd ratios were estimated using normal BMI and upper tertile of maternal height and leg length as the reference category.

Adjusted prevalence Odds Ratio (POR) were estimated from GEE models controlled for maternal age and anthropometry (as appropriate), child sex.

Mean maternal BMI, height, and leg length were associated with child anthropometry Table 2. Child stunting and underweight prevalence ranged 73-89% among mothers in lower tertiles of height and leg length. Mothers who were below the 1st tertile of

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height and lower leg length were associated with children who had higher (2.8-4.6 times) odds of stunting by Poisson models. The association remained significant and strengthened for maternal lower leg length-childhood stunting (OR=10.9) with adjustment for potential confounders. The maternal height-child stunting relation also strengthened but became non-significant in the multivariate model.

Table 3 shows results for ANOVA analyses for associations between child growth and maternal anthropometry. All child growth z scores are significantly and inversely associated with maternal anthropometry (BMI, height and lower leg length). For example, the mean length z score (HAZ) of children whose mothers were the lower tertile category of height was -2.6 SD, relative to -1.7 SD for their peers whose mothers were in the middle height tertile. Similarly, mean HAZ was -2.7 for children whose mothers were in the lower tertile of leg length were worse off compared with -1.7 (mother's in middle category).

Table 3: ANOVA Analyses results for the associations between mean Z scores of child growth measures with maternal anthropometry.

Maternal Measures	Mean Z-Score of Child Growth					
	HAZ	P-Trend	WAZ	P-Trend	WLZ	P-Trend
Underweight	-1.7		-2.5		-2.3	
Normal	-2.1	0.12	-2.7	0.08	-2.4	<0.01
Overweight	-2.3		-2.3		-1.3	
Maternal Height Tertiles						
Lower	-2.6		-2.5		-1.6	
Middle	-1.7	<0.01	-2.6	0.23	-2.4	<0.01
Upper	-1.9		-2.8		-2.6	
Mom Leg Length Tertiles						
Lower	-2.7		-2.9	0.04	-2.0	
Middle	-1.7	<0.01	-2.6		-2.4	0.07
Upper	-1.8		-2.4		-2.0	

HAZ – Length/Height-for-age z score; WAZ – Weight-for-Age z score; WFL – Weight-for-length z score.

As shown in Table 4, at baseline, child length-for-age z score (LAZ) was inversely associated with high risk for PEDS-language problems but not weight for age. The results indicate that children with higher LAZ were less likely to have PEDS-language development problems. No significant association was observed between child growth indicators and a high risk of development concerns. We note that this analysis was based on a sample size of 21.

Table 4: Regression analyses describing the associations between child growth indicators and high risk PEDS scores at baseline (N=21).

PEDS Outcome	High Risk Language, %		High Risk Development, %	
Child Growth Predictors	β (95%CI)	P-value	β (95%CI)	P-value
Weight-for-Age Z-score	-7.9(-31.0,15.2)	0.48	0.1 (24.9, 25.2)	0.99
Length-for-Age Z score	-3.1(-5.8,-0.3)	**0.03***	0.7(-2.3,3.6)	0.65
Sex	-4.9(-50.4,40.6)	0.82	23.0(-26.3,72.3)	0.34

All children had recurrent illnesses, with malaria reported in 60% of children at least once during the study period. Based on verbal report, it appeared that bed net use also increased but it was not possible to verify the data. Qualitative improvements were observed in all participants including healthy skin texture and hair and gains in developmental milestones.

Discussion

This pilot study demonstrated that a home-based nutrition education program that also makes provisions for healthy foods, clean and safe water, and RUTF led to improved physical markers of nutritional status (BMI underweight) as well as reduced number of developmental concerns for children with malnutrition in rural Ghana. The keys to success of the program were providing services in the home and community and a previously established trusting relationship with a local NGO due to years of providing a Village Health Outreach. Although comparable to other successful intervention strategies done with vulnerable youth [14], the context of interfacing directly by a weekly visit from a village assistant and a monthly nurse home visit is not routinely done in LMIC settings but appears to have contributed to positive outcomes.

All families identified with a child with malnutrition were eager to be involved in the study. It was interesting to note the

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high percentage of children (32%) living with family members other than the biological mother and such is reflective of Africa's strong extended family system support and the need of some adult parents to move to the city to find work. Although quantitative data on lessons learned by the participants and their families was not collected, many families indicated they learned the importance of nutrition to physical and young child brain development. All families appeared receptive to learning more about disease prevention, health promotion, safe and clean water and hygiene.

Challenges included efforts to find all families and ensure they were adherent to the weekly protocol. More than half had one family member with a mobile phone, but even with this, reaching them to remind of appointments was difficult and at times, they were not home. Despite the hurdles, the study had an 84% retention rate, and all families were appreciative of the intervention. This excellent recruitment and retention rate was likely due to the relationship and trust that Project OKURASE NGO established in the region and to the strong commitment and efforts of project staff to see the families make progress.

Physical Improvements

A physician and the two Ghanaian nurses completed the pre- and post-intervention assessments in the controlled setting of the NGO office. Despite this being a rather short intervention, it is encouraging that there was a statistically significant reduction in prevalence of underweight (based on BMI-for-age Z scores) children. Malaria and diarrheal illness contributed to poor weight gain. Children affected by stunting improved minimally. The smaller improvement in stunting is consistent with a chronic condition that may have started in utero due to poor nutrition [15], influenced by maternal stunting measured through leg length and takes a longer time to improve. It may also mean that the intervention's impact was not strong enough (or long enough) to improve stunting. Improved weight and head circumference often precede catch-up in linear growth and may represent a form of biological economics in this rural region of West Africa. This mechanism is plausible in this context as we observed reductions in all child growth indicators (low head circumference, wasting, and underweight) as well as stunting, albeit not as pronounced. Linear growth faltering is quite rapid in the first 24 months of life in many low to middle income countries [16].

Poor maternal nutritional status during preconception and maternal early life has been shown to be negatively associated with offspring growth indicators [17-20]. Maternal lower leg length, in LMIC countries, is a proxy for early life deprivation (including nutrition, poverty, morbidity etc.) [21-23]. The rather strong maternal anthropometry with offspring stunting in study suggests that the children might have experienced similar adverse growing conditions.

The marginal improvements in childhood stunting in this intervention program are not trivial, given the potential high background rate of growth faltering in this population. The results of this intervention are consistent with findings from other countries. For example, a randomized controlled trial (RCT) found a positive relationship between RUTF exposure with linear growth and head circumference of Bangladeshi children [24]. Similar results were shown in a study of children in Malawi [25], and a different part of Ghana [26].

Our program was associated with reductions in the proportion of children with developmental concerns. This is consistent with data from South America, where infants who received nutritional supplementation showed improvements in cognitive development [27]. Most prior studies have involved interventions different from that of the current study and so this pilot study is very timely. Our interventions showed an association between linear growth and PEDS High Risk-language (albeit n of 21). The project was associated with reduction in stunting and/or prevented continued linear growth faltering as the children aged. In part, this could explain the reduction in the number of developmental concerns in this population. This is consistent with data from studies from other countries [24], [26-28].

Developmental Screening

The primary purpose of this pilot project was to illustrate that developmental progress could be evident with improvement in nutritional status. Baseline and follow up developmental screenings from the PEDS-DM interview were used to complete the one-page PEDS screening instrument that was used in our statistical analysis. Most families were not aware of normal developmental milestones. Some deficiencies in development appeared to be at least partially related to lack of exposure or opportunity. Tests normed for the U.S. had to be adapted (e.g., questions about understanding light bulbs or walking upstairs or stacking blocks or scribbling with crayons or pencils were not always activities that the child had been exposed to or experienced). However, it was very encouraging that during the 9 months, using age-adjusted norms, developmental gains were evident with improvements noted. Although we utilized validated screening tools of development, these instruments only indicated a concern, since the instruments used were screeners and not comprehensive developmental evaluations. A food and diet journal that also included adherence to the protocol and monitoring of mosquito net use, as well as illness, was regularly requested; however, this was rarely reliably reported, as most of the participants were unable to read and write or did not recall a consistent historic record.

We chose to use nurses to conduct all physical measurements, as efforts prior to this study found this more reliable. However, this skill could be taught to devoted non-medical individuals in the village with practice and verification. After completing the study, it was encouraging that all families reported they learned

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about the importance of good nutrition for healthy development, and all felt that the study was helpful in the promotion of health and well-being. Children showed health improvements over the course of the brief intervention, and it is felt that a longer study would have shown greater improvements in all measures.

Our intervention is unique in a variety of ways. First, the intervention was in a real-world program and not an RCT setting. It was also a targeted intervention for malnourished children (MUAC < 13.5cm). Further, it is an integrated program with key features: a community support health team that had worked with the villages during the annual Village Health Outreach. The unique assistance provided by monthly home visitation and education promoted adherence to protocol and reinforced nutrition lessons. These characteristics contributed to the improved biologic impact in terms of child growth and development. The observed benefit of this integrated program aligns with a recent study that found a positive impact of a similar integrated infant and young children (IYCF) feeding program with RUTF and mobile community health worker visitation on child development scores of children in rural Katanga province of Democratic Republic of the Congo [28].

The nutrition education and monthly home visitation by the village nurses of this study likely improved adherence and encouragement of complementary feeding practices as was found in a Randomized Controlled Trial in Peru [29,30]. The findings of this work have broad implications in other settings as it followed the Community-Based Management of Acute Malnutrition (CMAM) framework. The improvements in child development observed might have a potential impact on cognitive functioning and school readiness at ages 5 and 6 years, as was shown in a prior study [26]. This finding, combined with improved nutritional status, indicates that these children are more likely to progress in school and later work productivity, as poor nutrition has been associated with IQ, schooling, and adult earnings in other LMIC [2-5]. In the long-term, if replicated on a larger scale, the improvements in this study could contribute to the human capital of the country.

Given the long-term malnutrition that most of the children faced, a longer intervention period would be useful, but the results of this relatively brief intervention are encouraging. Further work needs to be done on education on nutrient rich foods and sustainability of such an intervention in a low resource setting where parents cannot attain these foods and nutritious RUTF for themselves. Poverty and household stress are certainly barriers to meeting balanced diet needs for the children. In subsistence farming communities, there may be few protein sources. The value of protein, fruits, and vegetables is often not recognized. Infant, young child feeding practices (IYCF) is a recommended intervention for improving nutritional status of children, especially those in resource poor settings.

However, foods used in complementary feeding are often not nutrient-dense. As a result, RUTF is given directly to young children for improving nutrient density. As further work is conducted, considering how farm communities can shift to foods that are more nutritious will be a primary consideration to solving the malnutrition problem way forward. Finally, one child died from Kwashiorkor early in the project despite being admitted to the hospital and before being able to benefit from our intervention. This loss highlights the critical importance of prevention and early intervention starting prior to pregnancy if possible. Future studies should target education on the importance of nutrition for pregnant women.

During the last meeting, families were given the opportunity to give feedback on the study, to comment on whether it was helpful, and they were encouraged to give suggestions for future interventions. All indicated they had learned new facts and they felt they were more aware of the importance of nutrition for overall positive health. The comprehensive pre and post meetings with the health care team in the office facilitated an ability to talk privately about concerns. It was difficult to know for certain if the therapeutic medical food was given only to the child of interest. Despite coordinated planning and agreed upon communication methods, challenges included difficulty connecting through use of agreed upon family or neighbor cell phone, family forgetfulness about scheduled meetings and difficulty evaluating reliable adherence to protocol directions.

Limitations

This study demonstrated the feasibility and initial positive outcomes of an intervention project with home visitation in rural Ghana. However, this short intervention duration might not be long enough, as children need more time for linear catch-up growth, as well as time to show improvement with the intervention. Developmental assessment revealed that some children had a lack of exposure to some developmental opportunities (scribbling, climbing steps and stacking blocks). It is well recognized that malaria and diarrheal illness interfere with nutritional and developmental progress. Although recruitment and retention were positive, two families moved, and one child died.

Future Directions

The critical work completed in this pilot study and the lessons learned immediately inspired the next steps. Okurase village, in partnership with Project OKURASE, completed the construction of a quarter acre organic garden that is operational and used as a place to teach and demonstrate organic gardening methods. The organic garden is integrated into the village through a Montessori school that teaches young children how to grow food organically. Montessori school is in its sixth year of operation. Based on knowledge attained from this study, the school provides nutrition through healthy daily breakfast, lunch, and snacks. Provision of meals by a school is rare in Ghana. These efforts are an attempt to develop sustainable nutrition strategies among children and adults with the everyday foods they eat. A group of farmers in Okurase opened the Okurase Organic Farmers Association and

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they are operating solely with organic methods. Doing so will increase the availability and knowledge of healthy foods for all in the village. These local activities are important to sustainability of nutrition. However, for severe cases of malnutrition, home visitation interventions with lifesaving medical food (RUTF) or nutritious foods and medical assessment will still be important to provide and monitor for evaluation.

Conclusion

This pilot study demonstrates preliminary data on the benefit of a collaborative targeted, home intervention for young children with malnutrition in rural Ghana.

What is already known on this topic?

- On the topic of nutrition in low and middle-income countries, it is known that RUTF improves nutrition in severe cases.
- It is also already known that mother and child malnutrition are related.

What does this study add?

- This study adds to the literature the structure and components of a successful home-based program targeting nutrition and development in children in LMIC.
- This study also adds preliminary outcomes from this home-based program targeting nutrition and development.

Competing Interests

The authors declare that they have no competing interest.

Author's Contributions:

i. Eve Garlington Spratt: PI of the grant, provided scientific oversight, ran the project and wrote the manuscript.

ii. Carrie Papa: U.S based research assistant – entered data, communicated with the team in Ghana, participated in pre-study work in Ghana, organized the project on the U.S. side, helped write the manuscript, wrote the IRB submission.

iii. Yaw Addo: Lent his expertise on growth of children living in LMIC. He also ran all statistics.

iv. Bradley S Miller: Lent his expertise on growth of children living in LMIC. Assisted with editing the manuscript.

v. Bright Asunda: Ghanaian nurse who collected nutrition and development data and implemented the intervention, conducted anthropomorphic measurements, translated questionnaires.

vi. Raphael Gborkpah: Ghanaian nurse who collected nutrition and development data and implemented the intervention, conducted anthropomorphic measurements, translated questionnaires.

vii. Clifton Spratt Edwards: As a volunteer of Project OKURASE, he participated in preliminary data collection that informed the design of the study.

viii. Carlyann Eve Edwards: As a volunteer of Project OKURASE, she participated in preliminary data collection that informed the design of the study.

ix. Jennifer K Poon: Developmental Pediatrician who specializes in early growth and development. Guided selection of measures for the project.

x. Samuel Nkrumah Yeboah: Director of Project OKURASE and Chief of Development of Okurase village– assisted with engaging community for recruitment and retention purposes. Locally monitored the project staff. Assured support of the project from the NGO.

xi. Cynthia Cupit Swenson: Co-Director of Project OKURASE. Traveled to Ghana to advise on intervention implementation, assisted with writing the manuscript.

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