Weight Loss and Nutritional Status of 6-59 Months Children after Positive Deviance/Hearth Approach in Southern Benin Rural Area: Associated Factors to Later Underweight

Mariette Inès G. Zevounou[1], Waliou Amoussa Hounkpatin[1*], Flora Josiane Chadare[1,2], Jaurès H. F. Lokonon[1], Mohamed Soumanou[3] and Roch Mongbo[4]

[1]Département de Nutrition et des Sciences Alimentaires, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, Benin.
[2]Ecole des Sciences et Techniques de Conservation et de Transformation des Produits Agricoles, Université Nationale d'Agriculture, Benin.
[3]Unité de Recherche en Génie Enzymatique et Alimentaire, École Polytechnique d'Abomey Calavi, Université d'Abomey-Calavi, Benin.
[4]Laboratoire d'Analyse des Dynamiques Locales et des Etudes du Développement, Université d'Abomey-Calavi, Benin.

Authors' contributions

This work was carried out in collaboration between all authors. Authors MIGZ and WAH designed the study, wrote the study proposal, collected data, performed the statistical analysis and wrote the first draft of the manuscript. Author FJC contributed to the writing of the first draft of the manuscript. Authors FJC and JHFL managed the literature searches and reviewed the manuscript. Authors JHFL and WAH managed the analyses of the study. Authors MS and RM reviewed the manuscript. All authors read and contributed to successive versions of the manuscript and approved the final one.

Article Information

Original Research Article

Corresponding author: Email: amouswal@yahoo.fr;

ABSTRACT

Aims: To appreciate the evolution of weight gain by malnourished children and factors associated to children underweight after the Positive Deviance/Hearth sessions.
Study Design: Longitudinal study.
Place and Duration of Study: Districts Ze and Lalo (Southern Benin), from May to August 2014
Methodology: This study was conducted on 98 children aged of 6-59 months who fully participated in Positive Deviance/Hearth (PD/H). During one month, four measurements of weight have been taken on the 77th, 84th, 91th, and 98th day after the beginning of PD/H. Questionnaire was administered to mother on environmental, hygiene practices, and food accessibility of household. Relation among factors of food accessibility, household hygiene, and child nutritional status was sought by an Analysis of Factorial Components.
Results: The children who participated in 12 days of PD/H gained significantly 0.63 kg and 1.13 kg of weight in Lalo and Ze respectively ($P<.001$). From the 12th to 77th day after the end of PD/H, we noticed a significant weight loss from 10.54 to 10.09 kg in Ze and from 9.75 to 9.19 Kg in Lalo ($P=.003$). Prevalence of underweight children on the 77th day was 45.8% with 12.5% of severe case and 63.5% with 18.9% of severe case in Lalo and Ze, respectively. The severe underweight children were characterized by households where i) it rarely arrived to be without food ii) one member rarely have a day without eaten but iii) the drinking water is from well.
Conclusion: On the 77th day after the PD/H, the children of our study had weight loss. Food accessibility and household hygiene are mainly the limited factors that could explain the degradation of the nutritional status of children and high prevalence of underweight. This first study conducted in Benin on PD/H approach is more exploratory and helps to appreciate this approach efficacy and sustainability.

1. INTRODUCTION

In Benin, the nutritional situation of children remains a concern. About 18 % of children aged of 06-59 months are underweight and 4.5% are wasted. Stunting was about 34% indicating that the situation is delicate [1]. Malnutrition has multiple negative consequences on education, productivity, health, and survival and it affects the most vulnerable groups such as children and women [2-4]. In order to overcome this problem, Nutrition Rehabilitation and Learning Centers (NRLC) approach have been used in many malnourished districts in Benin to manage moderate acute malnutrition among children [5]. Unfortunately, programs that are developed by NRLC are usually not sustainable, possibly due to fact that they are not suitable with the socio-economic and environmental conditions of the beneficiaries [6]. By the way, it is urgent to develop endogenous approach adapted to life conditions of communities in order to efficiently reduce the prevalence of malnutrition in developing countries like Benin. Positive Deviance/Hearth (PD/H) appears to be one of the most efficient approaches [7,8]. The main goal of a nutrition rehabilitation project using the PD/Hearth approach is the sustainable rehabilitation of poorly nourished children. This approach has been experimented by many countries. In Senegal, during one year (2001) of PD/H implementation on experimental area, a reduction of 10% of malnourished cases was observed with lack of severe forms [9]. In Nepal, 73% of children have improved their nutritional status from severe to moderate [10]. In Mali and particularly in Sikasso areas, mothers who have participated in PD/H during six months have improved the feeding practices and their nutritional situation [11]. PD/H approach was recently introduced to Benin by PLAN-Benin NGO in the framework of a pedagogic Community Nutrition Program (2011-2016). The objective of this program was to improve the nutritional status of 16 800 young children in rural and poor areas where the prevalence of malnutrition was high. Moreover, financial support was given to 72 000 mothers and 24 000 grand-mothers in 10 districts of Benin through loaning service mechanisms. Before scaling up this intervention at the country level, it was necessary to identify factors related to community that can hamper the efficacy and sustainability of the learned practices during the PD/H approach implementation. The present study based on the case of two districts Ze and Lalo aimed to assess (i) the evolution of weight gain by malnourished children during and after PD/H and (ii) factors associated to underweight children after their participation to the PD/H and

when they return to their household get into their ordinary life.

2. METHODOLOGY

2.1 Study Setting and Participant Selection

This is a longitudinal cohort study where the repeated measures of weights were performed to appreciate the changes, specifically the variation of weight after PD/hearth. The same individuals have been observed repeatedly over the study period.

The study was conducted in six villages of two districts (Ze and Lalo) located in Southern Benin. Two Non-Governmental Organizations (CEBEDES and GRAIB) as local partners of the program had opened PD/H in these villages. Ninety-eight children aged of 6 to 59 months were randomly selected from the list of children having participated in PD/H and improved their nutritional status with weight gain superior or equal to 400 g within the 12 days of PD/H. After 12 days the children and their mothers returned to their house in their normal life and then received two home visits (once a month) by the community workers (Fig. 1) who perform various measurements.

2.1.1 Sample size

The following formula was used to calculate the sample size [12]:

$$n = \frac{U_{1-\alpha/2}^2 \times p(1-p)}{d^2}$$

Where $U_{1-\alpha/2}$ = 1.96 (standard normal variate at 5% type 1 error). P is the proportion of children who are rehabilited after Hearth. d=5% (Precision).

In Ze, p = 152/160 and n = 74 children, In Lalo p = 66/81, we have 237 children. As, we didn't find this number of children in Lalo, we applicate the rate of sample of Ze for Lalo. Thus, t = 74/152 = 0,48; t = n/66 = 0,48 => n = t x 66 , It gives n = 32 children in Lalo.

During the period of study, we have 8 absents. Finally, we have included 98 children in final analysis.

2.1.2 Description of PD/hearth

DP/H sessions consisted of 12-days grouping (hearth) of mothers with their children having moderate and acute malnutrition. The hearth sessions were conducted in the villages of each district. From 7 to 12 child–mother pairs participated actively in each hearth session. During the sessions, mothers were asked to provide local food ingredients available in their surroundings. The mothers contributed to the various food ingredients and session materials such as firewood, prepared complementary foods based on local recipes developed by local ONGs through a local market survey, and fed their children on the spot during the 12 days. Also, during the sessions, mothers were taught how best they can combine the local food ingredients to cook equilibrated dishes for their children. Practices of equilibrated dishes and culinary demonstration follow nutritional education session. Thus, mothers discussed about feeding, caring, hygiene, and health-seeking messages with the community workers. All enrolled children were weighed on the first and 12th day of the sessions. The steps of hearth session implementation are fully described by Nutrition Working Group, Child Survival Collaborations, and Resources Group [6].

2.2 Data Collection

2.2.1 Anthropometric measures

Weight and height of children were measured following standard procedures [13]. Height was measured using a height/length board to the nearest 0.1 cm. Weight was assessed using an electronic weight scale to the nearest 0.1 kg. Age of the children was determined using the immunization cards or home records of date of birth. The weight of children has been measured once per week during one month namely at the 77th, 84th, 91th, and 98th days after the beginning of PD/H (Fig. 1).

2.2.2 Water, hygiene, sanitation (Wash), and household food insecurity data

Information on factors that affect nutritional status of children was collected using a structured questionnaire. Mothers/caregivers were interviewed regarding hygiene practices and water source. In addition, information related to food accessibility and availability of households were estimated with the tool Households Food Insecurity Access Scale (HFIAS) [14] as proxy of household economic status during the last 30 days.
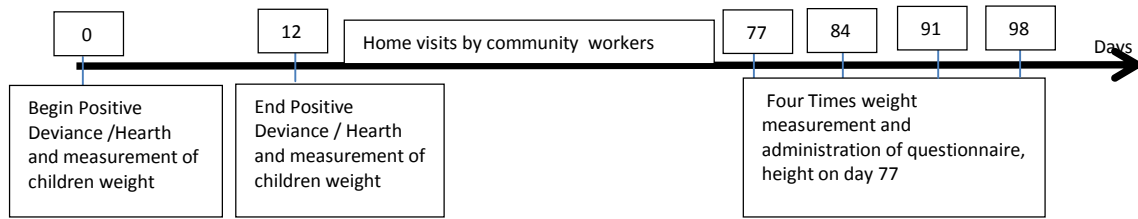
| 0 | 12 | Home visits by community workers | 77 | 84 | 91 | 98 | Days |

| Begin Positive Deviance /Hearth and measurement of children weight | End Positive Deviance / Hearth and measurement of children weight | | Four Times weight measurement and administration of questionnaire, height on day 77 |

Fig. 1. Design of the study

2.3 Data Processing and Statistical Analyses

2.3.1 Children nutritional status

The global nutritional status was appreciated on the 77th day after the beginning of PD/H using WHO Anthro software version 3.2.2 (2011). Height-for-age z score (HAZ), weight-for-age (WAZ), weight-for-Height (WHZ) values were calculated with the 2006 WHO growth reference [15]. Stunting was defined as HAZ<-2 SDs, wasting as WHZ<-2 SDs, and underweight as WAZ<-2 SDs. The prevalence of stunting, wasting, and underweight were calculated on the 77th day.

2.3.2 Studied factors

The studied factors could explain the variation of child weight observed between the 12th and 77th day after PD/H are the following: (i) food accessibility and availability of households (each of nine questions of HFIAS), (ii) Hygiene practices of mothers and children (cleanliness of house, kitchen, and room, availability of latrines, handwashing before cooking, before giving food to children and after using latrines) and (iii) source of drinking water (well water, Blackwater).

For understanding the nutritional situation of children on the 77th day, the underweight was classified into three groups: severe, moderate, and normal. The underweight was mainly used in the study because it was an indicator for the fieldworkers to monitor the malnourished children. PD/Hearth uses weight-for-age because it is the most sensitive indicator to the change and does not require the quality of height measurements, which are difficult to collect [6].

2.3.3 Variation of weight during PD/H (within 12 days)

T-test of student with paired data was performed on the weights to appreciate the weight gain before and after the PD/H. The normality test and equality of variance have initially been verified.

The median was expressed for the variables which are not normally distributed. These analyses were performed with R.3.0.2 software.

2.3.4 After PD/H (12th, 77th, 84th, 91th, and 98th days)

Analyses Of Variance (ANOVA) on repeated measures of weights were performed to appreciate the variation of weight after PD/hearth. The log neperian transform has been initially done to assure the multinormality and homoscedasticity of data. Adjusted means estimates were used to follow children weight by the studied factors. Relation between the studied factors of household and child nutritional status on the 77th day was established through a Factorial Components (AFC). For this analysis, the different categories of underweight (severe, moderate, and normal) were used. All these analyses was performed with SAS 9.2 software.

3. RESULTS

3.1 Distribution of Children by Age

The mean of children's age was 32.32 ± 16.60 months. In Lalo, the mean was 27.25 ± 18.52 months and 33.96 ± 15.71 months in Ze. The majority age of children (59%) varied from 24 to 59 months (Table 1). The ratio Boys/girls was 1.04. So, boys (51%) and girls (49%) were almost equally represented.

Table 1. Description of sampling

Infant characteristics	% or mean ±SD	Total
6-23 mo (n=40)	40.81%	98
24-59 mo (n=48)	59.19%	98
Boys (50)	51.02%	98
Girls (48)	48.97%	98
Sex ratio (Boys/Girls)	1.04	98
Mean age in Lalo	27.25 ± 18.52 mo	24
Mean age in Ze	33.96 ± 15.71 mo	74
Mean age (all)	32.32 ± 16.60 mo	98

3.2 Variation of Weight during the PD/H

PD/H had a positive effect on children ponderal growth. In fact, children who participated in 12 days of PD/H sessions gained 0.63 kg and 1.13 Kg weight in Lalo and Ze respectively (Table 2). The weight variation before and after PD/H in each district was significant ($P<.001$).

3.3 Variation of Weight after PD/H

We noticed a weight loss in the two districts between 12th and 77th day after the beginning of PD/H. This weight loss remained stable by the time until the 98th day during a month of follow up (Fig. 2).

3.4 Child Nutritional Status on the 77th Day after PD/H

On the 77th day, median of WAZ and HAZ were -2.24(0.00- -2.01 95% CI) and -2.24(0.00 - -2.32 95% CI) respectively. The mean of WHZ was -1.00 ± 0.93. The prevalence of stunting in Ze was about 74.3% with 43.2% of severe cases. In Lalo, this prevalence was 47.8% with 17.4% of severe chronic malnourished children. The prevalence of wasting in Lalo was 20.8% with 4.2% severe cases and in Ze; we have also noticed 12.2% of wasted without severe cases. In Lalo, the underweight children prevalence was 45.8% with 12.5% of severe cases and in Ze, this prevalence was 63.5% with 18.9% of severe.

3.5 Food Accessibility and Availability of Households

The HFIAS survey revealed that hundred percent of households in Lalo and 85.1% in Ze, were not able to have enough food in time or sometimes do not have the possibility to eat the food that they would prefer or have to follow a diet with the available food which is not always adequate. In Ze, 4.1% of households usually sacrificed food quality and followed a monotonous diet with non-preferred foods or sometimes they frequently reduced the quantity of food by reducing the number of meals per day or the quantity of food per meal. Moreover, only 10.8% of the households in Ze faced none of the conditions of food insecurity (accessibility) or rarely care about it.

3.6 Water, Sanitation, and Hygiene Practices of Mother (WASH)

WASH practices in the two districts showed that 50-80% of children were living in a clean environment (cleanliness of house, kitchen and room). In addition, practices of handwashing before food preparation and before eating were observed by 93-100% of children and their mothers/caregivers in the two districts. However, only 25% of surveyed households had a latrine. In the two districts, more than 66% of children washed their hand after defecation in latrines or in the wild. Well water and backwater are the main sources of water supply. In Lalo, a majority (75%) of household used well water as drinking water whereas 61% used backwater in Ze. Also, pump water is used by a minority of household (12.2% in Ze and 4.2% in Lalo).

3.7 Association between Food Situation, WASH and Underweighted Child on the 77th Day (AFC)

Factorial Component Analysis that the first two components have explained the totality of initial information, has revealed that the moderate underweight children were characterized by household where

- one member cannot eat its preferred food or, where
- one member ate limited variety of food or, where
- a member ate food against his willingness or, where
- a member ate small food portion, where
- a member went to bed hungry with no possibility for having diner and
- Household whose children wash hand before eating.

The severe underweight children were characterized by household where

- it rarely arrived to be without food
- one member rarely has a day without eaten
- but the drinking water was well water.

Furthermore, the children who were not underweighted were characterized by household where one member has sometimes eaten a small meal but observed good hygiene practices (Fig. 3).

4. DISCUSSION

This study was proposed to assess the nutritional status of children after their participation in PD/H and to identify factors associated to underweight status.

Table 2. Evolution of children weight during deviance positive/Hearth by district

Districts	Before PD/H		After PD/H		P-Value
	Weight (kg)	CV (%)	Weight (kg)	CV (%)	
Lalo	9.35	31.42	9.98	29.80	P<.001
Ze	9.70	21.15	10.83	19.81	P<.001

PD/H: Deviance positive/Hearth. CV: Coefficient of variance
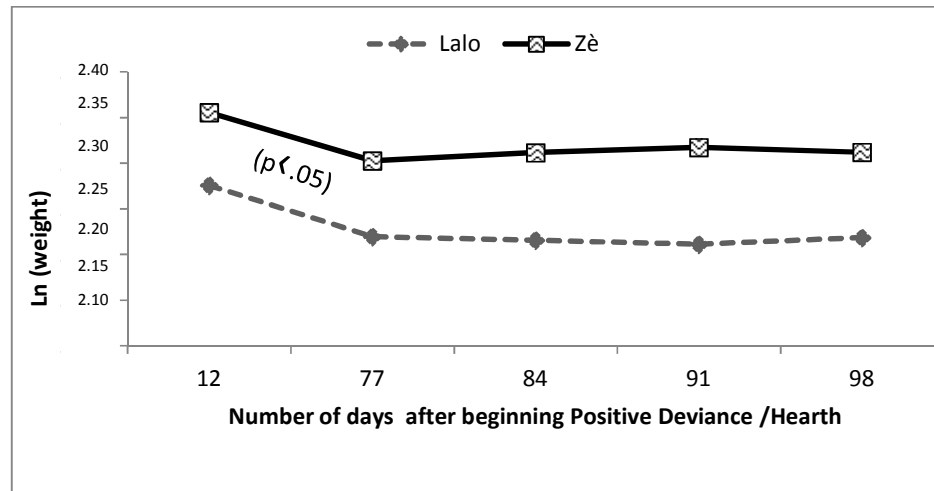
Fig. 2. Variation in children weight per district after the positive deviance /hearth

The high prevalence of stunting, wasting, and underweight in the area after PD/H is discouraging. In Lalo, whatever the form of malnutrition, the prevalence showed an emergency situation. In Ze, prevalence of stunting and wasting showed an alert situation according to WHO norms [15]. This situation could be explained by the period in which the study was conducted and the chronic precariousness of household being in welding period. Many studies showed seasonal variation of the nutritional status within children in many countries such as Benin [16,17]. Similar results were obtained in other municipalities of Benin (unpublished works) were weight loss is noticed after DP/H. Like this paper, it will be interesting to publish them for better documentation of the situation in order to find adequate solution.

The high prevalence of stunting is not surprising because many children are in advanced age while their nutritional status didn't improve by the time. Indeed, children mean age was 32.32 ± 16.60 months and more than half of the children was 24 to 53 months old. It is known that stunting begins during the first months of children and increases with time in inadequate condition [1]. This finding shows that the poor nutritional situation is due to inadequate food and hygiene practices of mothers during the years preceding the study. The participation of children to PD/H

does not apparently have an effect on their environmental and social conditions.

In this study, we were interested in underweight because the parameter that allows the children to leave the hearth was weight gain (superior than 400 g). The variation of children's weight before and after the hearth revealed that children have gained 0.63 kg in Lalo and 1.13 kg in Ze (Table 2). Our results were superior to the cut-of-point (≥ 400 g) allowing adequate weight gain and could be explained by the fact that during 12 days, the children consumed foods that improved their nutritional status. This case may mean that the PD/H provided an additional diet with foods that ensure adequate intake of proteins, energy, and micronutrients [18]. In addition, during the hearth sessions, the community volunteers and people in charge of children feeding, implement new recipes and efficient advices related to nutritional adequate food cooking, hygiene, and care for the rehabilitation of malnourished children [9]. In Vietnam, a control case study revealed a 40% reduction in malnutrition compared to a similar socio-demographic zone that did not receive the hearth intervention. Thus, overall nutritional status improved by weight –for –age Z score 0.3 [18]. The hearth had positive effect on child's growth [18] at least during the time of its implementation.
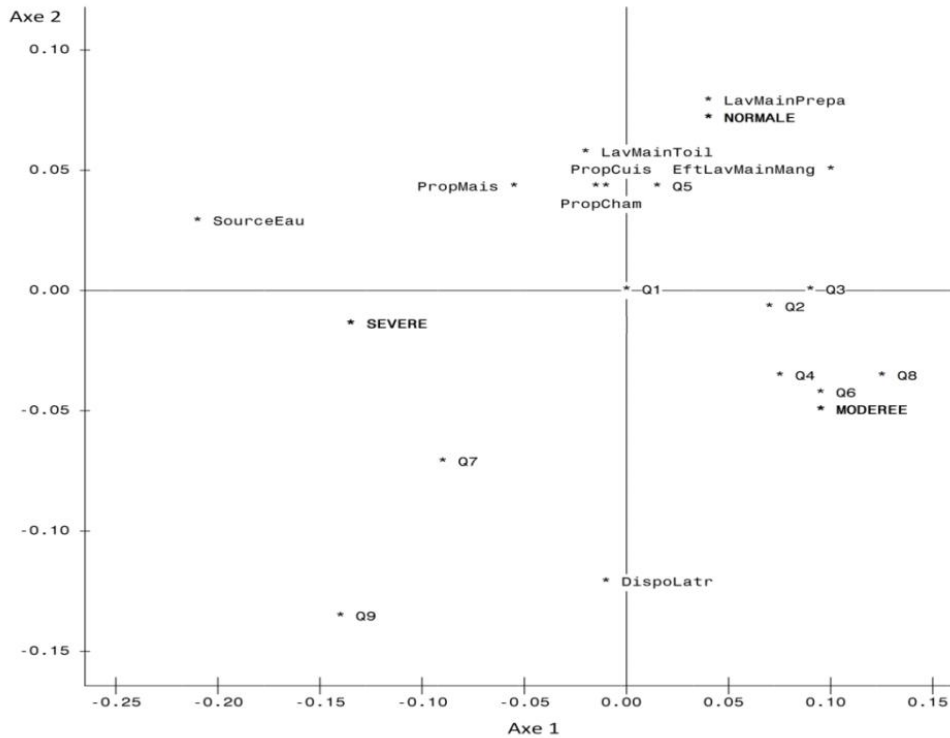
6

Fig. 3. Projection of underweight and factors in the factorial system axis

Legende : Q1 : Household worried by food shortage, Q2 : Household where one member could not eat its preferred food, Q3 : household where one member ate limited variety of food, Q4 : Household where a member ate a food against his willingness; Q5 : Household where a member ate a small food size; Q6 : Households where members had less than one meal per day; Q7 : Households experiencing food shortage (no food available); Q8 : Household where a member went to bed hungry with no possibility of having diner, Q9 : Household where a member had nothing to eat for a whole day. MODEREE: moderate underweight, SEVERE: Severe Underweight, NORMALE: No underweight. . PropMais : cleanliness of house, PropCuis : Cleanliness of kitchen, PropCham : cleanliness of room, DispoLatr : availability of latrines in house, LavMainToil : handwashing after using of latrines by child, LavMainPrepa : handwashing before the cooking, EftLavMainMang : handwashing before given of eat to child, SourceEau : source of drinking water

Moreover, the weight loss on the 77th day after the PD/H corroborate with the observed high prevalence of underweight (45.8% with 12.5% for severe case in Lalo and 63.5% with 18.9% for severe case in Ze) during the follow up period. Like in certain countries such as Haiti , these results in the concerned zones do not ensure the sustainability of PD/H [9]. Indeed, this fact also justifies the reason why we were interested in seeking factors that reduce again the nutritional status of children after the PD/H. May be the best practices related to feeding and WASH are not fully anchored in mothers' behaviors. Handwashing after toilet is not yet well integrated in the habit of children. Water sources (well water and backwater) that are used by most of the households of Lalo for their different food needs exposed children to diarrheal diseases and even environmental enteropathy. Poor hygiene and absence of adequate sanitation may play a role but evidence to support a causal relationship is largely lacking. Living in poor sanitary conditions may induce gut dysfunction [19,20] referred to as environmental enteric dysfunction. In our study, children without underweight belong to households where hygiene practices were observed. Children with moderate underweight belong to households where hands were washed before eating and those with severe underweight belong to households where well water is used as main source of water. In addition, conditions of households related to food insecurity are determinant for the nutritional situation of children. In Southern Benin, Kouton [21] and our study areas, Amoussa [16] and Sossa [22] had found that the food diet of children was not diversified and contains no animal protein and limited vegetal protein. It has been noticed that

children with severe underweight were also the ones that had monotonous feeding.

The changes in the nutritional status of the children after the nutritional rehabilitation partly depend on the food situation of their households. This may explain the high prevalence of underweight in the 77th day after the PD/H. Finally, the nutritional status of children is determined not only by the quantity of the food that is served but also by the quality. These aspects are not considered in the HFIAS tool. Many investigations must be conducted to deeply explore the factors associated to the weight loss after PD/H. Thus, countries that want to generate and sustain broad-based wealth must find scaling-up nutritional interventions which are among the best investments they can make [23]. In Mali, after six months, 60% of mothers practiced appropriate weaning techniques and 85% of children got an improvement of their nutritional status. The improved underweight situation of children persisted after PD/H. Prior to using the PD approach, growth monitoring sessions had had little success with malnourished children [6]. In Haiti, 60-70% of PD/Hearth children, who have been followed for three to six months after the Hearth session, were growing as fast as or faster than the international standard for weight and age [6,24]. About the 30-40% who were not growing normally, studies found that half of them had a hidden infection, mostly tuberculosis, and the others lived in extreme poverty. These children were either treated or enrolled in a poverty lending program based on the situation [6,24]. Prior link with the formal health sector staff is critical to ensure that a referral mechanism for these children exists.

5. POTENTIAL LIMITATIONS OF THE STUDY

The cross sectional nature of this study makes causal relationship between underweight on the 77th day and studied factors which is less probable. Moreover, since the study has been done in two areas in Southern Benin, it could be difficult to make generalizations. However, as it was conducted in rural area of the country, it will give us an initial base for the sustainability of Hearth.

In addition, even if it would cost of additional means, some measurements between 12th and 77th days may have provided more information on weight loss evolution after PD/H. We didn't

have the opportunity to investigate certain aspects like morbidity, socio economic factors, poverty that could significantly contribute to the degradation of the children nutritional status after PD/Hearth in Lalo and Ze. So, this study opens a large research field that could more document the current situation before the scaling up of this approach in the whole country.

6. CONCLUSION

In Lalo and Ze, the Positive Deviance/Hearth approach has rehabilitated the moderate malnourished children within the duration of its implementation. However, 77 days after the PD/H, weight loss was observed among these children. In their households, food accessibility and household hygiene factors limit the sustainability of the best practices learned during the PD/H sessions which could explain the degradation of the nutritional status of children and the observed high prevalence of malnutrition.

This first study conducted in Benin on PD/H approach was more exploratory and helped to appreciate its efficacy and sustainability. It will be important that other research studies based on morbidity, poverty, cultural, and socio economic factors are conducted in order to ensure the sustainability of this endogenous PD/H approach. The level of appropriation of taught lessons by mothers during the hearth session should also be considered.

CONSENT AND ETHICAL APPROVAL

The protocol for the research project has been approved by a suitable constituted Ethics Committee of University of Abomey-Calavi. Informed consent was given by children primary caregivers or the head of households.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. GdB, Enquête par grappes à indicateurs multiples (MICS), 2014, Résultats clés. Institut National de la Statistique et de l'Analyse Economique (INSAE). Cotonou, Bénin; 2015.

2. Black RE AL, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, et al. Maternal and child undernutrition: Global and regional exposures and health consequences. Lancet. 2008;371.

3. Black RE MS, Bryce J. Where and why are 10 million children dyingevery year? Lancet. 2003;361.

4. Caulfield LE dO, Blossner M, Black RE. Undernutrition asan underlyingcause of child deathsassociated with diarrhea, pneumonia, malaria, and measles. Am JClin Nutr. 2004;80.

5. Gouvernement du, Benin. Protocole National de Prise en Charge de la Malnutrition Aigue (PCMA), Ministère de la Santé; 2015.

6. CORE group, positive deviance / hearth: A resource guide for sustainably rehabilitating malnourished children, Washington, D.C. Washington, Etats-Unis: CORE Incorped. 2002;200.

7. World Health Organization, multicentre growth reference study group. WHO child growth standards based on length/height, weight and age. Acta Paediatr Suppl. 2006;450:76-85.

8. ZEITLIN M, et al. Positive deviance in child nutrition: With emphasis on psychosocial and behavioral aspects and implication for development United Nations university; 1990.

9. BASICS II/USAID, Approche des foyers d'apprentissage et de Réhabilitation Nutritionnelle Utilisant la Positive Déviance, USAID: Sénégal. 2001;27.

10. Grobler Tanner and C, Comments on manuscript review; 2001.

11. MARSH D, et al. Design of a prospective, randomized evaluation of an integrated nutrition program in rural Viet Nam. Food Nutr Bull. 2002;23(suppl 4):36-47.

12. Charan Jaykaran, Biswas Tamoghna. How to calculate sample size for different study designs in medical research? Indian Journal of Psychological Medicine. 2013; 35(2):121-126.

13. COGILL B. Guide de mesure des indicateurs anthropométriques. Projet d'Assistance Technique pour l'Alimentation et la Nutrition A.p. le and D.d. l"Education, Editors. Washington D.C. 2003;110. French

14. COATES J, SWINDALE A, BILINSKY P. Households food insecurity access scale: Guide of indicators. Food and Nutrition Technical Assistance Project (FANTA) and Food and Agriculture Organisation, Washington, D.C; 2007.

15. WHO, Utilisation et interprétation de l'anthropométrie. Rapport d'un comité d'experts, in Indicateurs de nutrition pour le développement: Guide de référence. FAO: ROME, Italie. 1995;69.

16. Amoussa W. Evaluation du potentiel de couverture des besoins en vitamine a des jeunes enfants à partir des sauces accompagnant les aliments de base consommés au Bénin, in Université de Montpellier 2. Montpellier, France. Thèse de Doctorat. 2011;266.

17. Ategbo E.A, Food and nutrition insecurity in northern Benin: Impact on growth performance of children and on year to year nutritional status of adults. Wageningen, Netherlands. 1993;150.

18. Wollinka O, Burkhalter KE, Bahir N. Hearth nutrition model: Applications in Haiti, Vietnam and Bangladesh. Published for the U.S. Agency for International development and world relief corporation by the basic support for institutionalizing child survival (BASICS) Project; eds. Arlington, VA; 1997.

19. Keusch GT RI, Denno DM, Duggan C, Guerrant RL, Lavery JV, Tarr PI, Ward HD,Black RE, Nataro JP, Ryan ET, Bhutta ZA, Coovadia H, Lima A, Ramakrishna B, Zaidi AK, Burgess DC, Brewer T. Implications of acquired environmental enteric dysfunction for growth and stunting in infants and children living in low- and middle-income countries. Food Nutr Bull. 2013;34:357-364.

20. Mbuya MN, Humphrey JH. Preventing environmental enteric dysfunction through improved water, sanitation and hygiene:

An opportunity for stunting reduction in developing countries. Matern Child Nutr; 2015.
DOI: 10.1111/mcn.12220

21. Kouton Sandrine E, et al. Caractérisation de l'alimentation des jeunes enfants âgés de 6 à 36 mois en milieu rural et urbain du Sud–Bénin Journal of Applied Biosciences. 2017;110:10831-10840.

22. Sossa Charles Jérome, et al. Evaluation of feeding practices in children aged 6-23 months in Southern Benin rural setting. International Journal of TROPICAL DISEASE & Health. 2015;10(4):1-8.

23. Hoddinott J, et al. The economic rationale for investing in stunting reduction. Maternal and Child Nutrition. 2013;9(2):69–82.

24. Berggren W, Grant J. Community Health Report to the Grant Foundation; 1995.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/19273