

Journal of **Medicine, Nursing & Public Health**



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How to cite this article: Kaguamba K, K. & Kebaabetswe P. (2018), Rate of Weight Gain in Malnourished Children in the Malnutrition Rehabilitation Program in Bobirwa. *Journal of Medicine, Nursing & Public Health* Vol 1(1) pp. 24-37.

Abstract

The rate of recovery from malnutrition is an important factor in malnutrition rehabilitation programs (MRPs). The longer a child stays in the malnourished state, the more the irreversible effects of malnutrition, especially regarding neurocognitive development, get established in the child. In Bobirwa District Botswana, it is not known to what extent and how fast malnourished children recover from malnutrition. The objective was to establish the rate and degree of weight gain in malnourished children on the program. Between August 2015 and August 2016, we enrolled 101 malnourished children in a prognostic cohort study. We tracked changes in anthropometric measures in the children. Subjects were followed for four months. The study found out that the weight after 4 months of follow up was significantly higher ($t = -6.22$ $df = 72$, $p = 0.000$, $d = 0.83$), being 5.87% higher than the baseline. There was no association between age and degree of malnutrition (weight for age and height for age scores). There was no association between age and the degree of weight gain. The study showed no effect of food variety and weight gain. The study found no association between the type of caregiver and improvement in nutritional status. The study concluded that weight increased after 4 months is statistically significant. However, the rate of increase is only a tenth of the least acceptable rate. This means the program is performing poorly in rehabilitating malnourished children. Reorganization of the program, perhaps change of the feeding product, is recommended.

Keywords: *Malnutrition, Child Growth, Infant Nutrition, Complementary Feeding & Child Health.*

1.1 Introduction

Child growth and development (G&D) is a complex process. It is influenced by a multitude of factors which might be broadly grouped into genetic, environmental and social, all of which have to be addressed preferably simultaneously when designing interventions¹. These factors vary in proximity to the plight of the individual child or family and have to be addressed by a variety of stakeholders in the health system.

The first two years of life is the period of the fastest G&D. When the process is curtailed, the effects, especially on neuro-cognitive development, are profound and to an extent irreversible, especially if correction is not prompt and effective². When malnourished children are put on a program that is successful to correct their anthropometric measures, the cognitive function lags behind and is never restored to reach its full potential³.

The most visible effect of malnutrition receiving most attention is childhood mortality, where up to forty five percent of childhood deaths worldwide are directly linked to malnutrition⁴. Malnutrition causes death through protein, energy, and micronutrient depletion, with resultant reduction in immunity, anemia and weak connective tissues. This results in vulnerability to common killer childhood illnesses such as pneumonia, diarrhea and so forth.

There are several non - fatal effects. Firstly, there is sub- optimal growth in form of stunting and limited neuro-cognitive development. The individual is unable to realize physical and intellectual potential.⁴ Secondly, maternal under - nutrition contributes to fetal growth restriction, which increases the risk of neonatal deaths and, for survivors, stunting⁵. Thirdly, malnutrition seems to have an effect on future generations. Children of malnourished children also tend to be smaller. This effect is likely to be both epigenetic and environmental, where generations are trapped into an unfavorable environment for optimal gene expression, which results in curtailment of growth⁶. Lastly, malnutrition has negative effects on the national economy. In relation to the last three facts, performance in school is affected. This will in turn lead to economic disadvantage of individuals and communities, which, especially if widespread will affect the national and even global economy.

All these effects illustrate the importance of a robust surveillance system and a process of urgent restoration of the body's nutritional status.

In the light of the foregoing, there are several reasons for appraising the Bobirwa District MRP.

Firstly, when auditing records of children admitted with Severe Acute Malnutrition (SAM), it is common to find that they are discharged for follow up mostly in facilities different from where they were admitted. The link between the hospitals and the follow up facilities is not well structured. Even when they are followed up in the outpatient departments of the admission facilities, inpatient and outpatient records are poorly linked if at all. This means that the health system cannot ascertain what happens to the children after discharge.

Secondly, records indicate that a child who is admitted with SAM is likely be readmitted several times with the same problem. There is usually poor adherence to follow up plans due to social instability and other socio-economic problems. These issues are addressed in policy documents describing the MRP. However, there is no evidence they are implemented on the ground. The caretaker is often referred to the social worker. There is however no formal communication between the social worker and the other service providers to ensure that the caretaker actually was seen by the former. This means that the socio-economic determinants of malnutrition in

these individual children are not addressed, and they end up with repeated admissions before they succumb to illness.

These observations inform the hypothesis in this study that the program has suboptimal success in rehabilitating malnourished children. This program has not been evaluated before, and therefore the success in achieving adequate weight gain and the rate of improvement has not been studied. The objective of the study was to ascertain these aspects of the program.

1.2 Materials and Methods

This was a prognostic study to study the outcomes of children diagnosed with malnutrition. The outcome of interest was completion of 4 months of study or 10% weight gain from baseline while the prognostic factors studied included age of children, age of caregivers, and variety of foodstuff consumed. Between August 2015 and August 2016, we enrolled 101 pairs of malnourished children with their caregivers. They were identified in the CWCs in Health facilities.

Selection criteria

Children between 6 and 59 months with any degree of malnutrition with good appetite and no co- morbidities.

Exclusion criteria

Inability to feed orally, poor appetite, sick looking or having known co-morbidities, like TB. HIV status was not specifically asked for and was not an exclusion criterion if there were no co-morbidities.

At recruitment, informed consent was obtained. A questionnaire was administered by a trained research assistant documenting the subjects' demographics, information on household food security, income and diet habits. Caregiver knowledge, attitudes and practices (KAPs) on causes of malnutrition was obtained. Anthropometric measurements (weights, height/length, mid upper arm circumference) were taken on the malnourished child at baseline. Measurements were taken by the routine clinic staff and accorded to the research assistant.

No additional interventions other than the ones routinely given in the regular rehabilitation program as described above were given in the study. The dyads were followed up on monthly basis. On each visit, a questionnaire was administered capturing information on any morbidity occurrence and how they were addressed, mode of care, feeding habits of the child and food availability for the family.

Follow up anthropometric measures were taken to detect any improvements or otherwise. The subjects were followed up until their weights improved to 10% of baseline or completed 4 months of study. Data was entered in excel spreadsheet. The weight and length was used to calculate z standard deviations (z scores) using the WHO anthropometric measure version (3.2.2) calculator. Analysis was done using SPSS software.

Sample size

Sample size calculation was based on a district population of 8, 254 under five children and a malnutrition rate of 4%. This translates to an estimate of 331 children eligible for the study (study population). We wanted to detect a 10% change in their weight. The power of the test was

set at 80%, and a margin of error of 5%. This gave a conservative number of 82 children. Those who completed the study were 101 and these are the results analyzed.

1.3 Results

Demographic characteristics

Sex:

There were 54 (52.4%) males and 47 (45.6%) females. N=101

Age

The positive skew in the graph in Figure 1 indicates that the malnourished children tended to be younger. The median age is 24 months, and an Interquartile Range of 22 months (Q1 of 15 months, Q3 of 37 months).

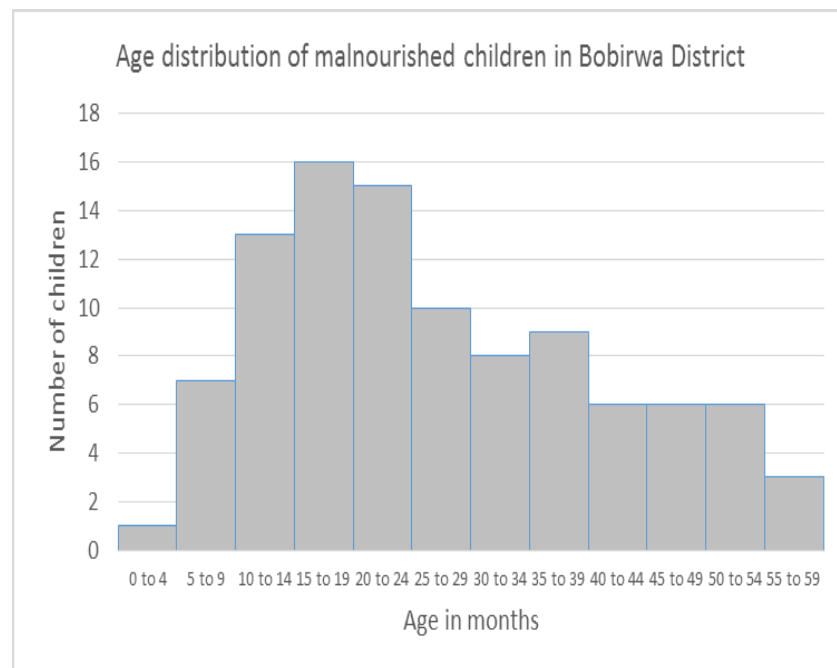


Figure 1: Age Distribution

Weight for age profile:

There were 99 children with reliable weights, and 76 children with reliable heights recorded as shown in Table 1.

Table 1- Weight for age z scores of malnourished children in Bobirwa District

Magnitude of deviation (standard deviations) from normal	Weight for age (WAZ) (Number of children (%))	Height for age (HAZ) (Number of children (%))
0 to 1 (neg)	5 (5.1%)	7 (9.2%)
1.1to 2(neg)	21 (21.2)	11 (14.5%)
2.1 to 3(neg)	46 (46.5%)	22 (28.9%)
Above 3(neg)	27 (27.3%)	36 (47.4%)
Total (n)	99 (100.1%)	76 (100%)

Entering their details in the WHO Anthropometric calculator resulted in z scores. As can be appreciated, more than 70% of the malnourished children are in the moderate to severe category (above 2.1 WAZ score). Severe stunting (above 3sd) affects close to 50% of malnourished children.

These results indicate that malnourished children at diagnosis are likely to be severely affected by the nutritional deficit.

Weight gain

We conducted a paired t test between the initial weight and the weight after 4 months.

In the tests for data suitability, the differences of the weight were normally distributed as shown by visual inspection of the box plot. There were 2 outliers. We examined them to determine their occurrence. We determined they were genuine, and so they were retained. Normalcy was not violated as demonstrated by the Shapiro- Wilks test for normality, whose level of significance was 0.096.

As for weight changes, (*weights reported here are mean weight in kg $\pm$ standard deviation*). The weight after 4 months of follow up was significantly higher ($t = -6.22$ $df=72$, $p=0.000$, $d=0.83$). The mean increase in weight was 0.58kg, (95% CI 0.41 to 0, 71). The initial mean weight was 9.35 ± 0.25 compared with 9.89 ± 0.26 at the end of 4 months, which is an increase of 5.87%. This information is summarized in the Table 2.

Table 2: Weight changes in malnutrition rehabilitation after 4 months of therapy

Category	Mean	Std. Deviation	Std. Error Mean	t value(p-value)
Initial weight	9.3452	2.02704	0.23725	
After 4 th month	9.8945	2.12896	0.24918	-6.22(0.000)

This indicated there was a significant but modest net weight gain in the sample.

1.3.1 Correlation between age and degree of malnutrition

A Spearman's correlation test was run to test the relationship between age and degree of malnutrition. Preliminary scatter graphs of both measures indicated poor monotonicity indicating poor correlation. The Pearson's Correlation values were -0.147 ($p=0.464$) and 0.039 ($p=0.861$) for underweight and stunting respectively. Thus, there was no significant association between either of these two parameters and age. Table 3 in the appendix summarizes these findings.

Table 3: Correlation between age and degree of underweight and stunting

	Underweight	Stunting
Pearson Correlation	-0.147	0.039
P value	0.464	0.831

Therefore, there was no significant correlation between age and degree of malnutrition ($r = -0.147$, $p = 0.464$).

1.3.2 Correlation between mother's age and degree of stunting

A Spearman's correlation test was run to test the relationship between age and degree of stunting. Preliminary analysis indicated poor monotonicity as assessed by visual inspection of the scatter graph. The test statistic (r) was 0.003 with a p value of 0.983, indicating no correlation between age and degree of stunting. These results are illustrated in Table 4.

Table 4: Correlation between mother's age and degree of stunting

		Age of mother	Degree of Stunting
Age of mother	Pearson Correlation	1.000	
	Sig. (2-tailed)		
Degree of Stunting	Pearson Correlation	-0.003	1.000
	Sig. (2-tailed)	0.983	

1.3.3 Association between age and the rate of weight gain

A visual observation of the scatter graph indicated a flat trend indicating no association between age of the child and rate of weight change.

The bivariate regression results confirmed that the age of a child and rate of weight gain were insignificantly associated ($r=0.106$, $p = 0.353$).

Food variety

At each follow up visit, the subjects were asked to state the number of food items (grouped into food categories) they had consumed over the last 48 hours. The results were as illustrated in Table 5.

Table 5: Differences in the weight gains between subjects categorized by difference in consumption

Number of food items (grams) (grams)	Number of subjects Median weight gain	Mean weight gain in the category		Chi (p Value)
1	6	0.52	0.65	
2	4	0.28	0.45	
3	8	0.45	0.25	
4	7	0.71	0.65	
5	12	0.58	0.3	
6	17	0.59	0.6	
Above 6	9	0.74	0.5	$\chi^2 = 6, df=6, p= 0.423.$

A Kruskal Wallis H test was run to test for differences in the weight gains between subjects categorized by difference in consumption of different numbers of food categories. There was no significant difference in weight gains $\chi^2 = 6$ at 6 df, $p= 0.423$.

Therefore, there was no correlation between food variety and degree of weight gain.

1.3.4 Correlation between type of caretaker and weight gain

Table 6 is an illustration of the degree of weight gain as related to different categories of caregiver. A Kruskal Wallis H test was run to find out if category of usual caretaker influenced the rate of weight gain. The test statistic value (χ^2) was 6 (df=6, $p= 0.423$).

Table 6: Correlation between weight gain and type of caretaker

Caretaker	Number of subjects	Mean weight gain	Kruskal Wallis H test
Mother	44	0.49	
Grandmother	16	0.43	
Auntie	2	0.8	
Father	3	Incomplete data*	
Father supporting other caregiver	4	0.5	
Other (more distant relative)	5	1.35	$\chi^2 = 4, df=4 p=0.406$

*Did not complete study- final weights unavailable.

Therefore, the type of caretaker did not influence the rate of weight gain in our study sample.

1.4 Discussion

Growth (described as increase in the size and weight) and development (described as advancement in capabilities of function) are simultaneous interrelated processes that depend on genetic and environmental factors for optimum occurrence². One of the most vital environmental factors is adequate nutrition. In this regard, although there are no globally accepted indicators for growth and development³ weight gain can be regarded as an approximate indicator of adequacy of overall growth and development occurring under normal physiological conditions or in the process of recovery from malnutrition⁴.

Overall, this study shows that after 4 months into the program, children put in the program gained 0.58kg, which is 6.27% of the initial weight. A p value of 0.000 and a Cohen's d of 0.83 is an indicator that the increase is likely to be real and unlikely to be by chance.

However, the magnitude of increase over 4 months of therapy is only 0.58kg, which is only 145g per month. Our sample had a mean weight of 9.25 kg. This means our cohort gained weight at a rate of 0.52g/kg/d, which is 15 times less than the recommended 8 g/kg/month⁵.

Several possibilities may be reasons behind this dismal performance. One may be the products used being unable to deliver enough nutrients to rehabilitate children at the acceptable rate, or that these products are not delivered to the needy children efficiently.

In Mali, Ackatia- Armah and colleagues did a prognostic cohort study designed to compare efficacy of 4 different products in improving malnutrition rate in the population. The slowest product achieved a 2.05kg gain in 57.9% of the cohort on it in 12 weeks, a gain of 0.683g per month⁶. Therefore, our cohort with 0.145g per month performed poorly in comparison.

Two other comparable studies illustrate the dismal performance of our study. One was done in Bangladesh and achieved a rate of 5 g/kg /day, and the other in South Africa where a rate of 6 g/kg/day was attained⁷.

This low rate of weight gain is significant taking into consideration that our results demonstrate that the screening process in the district detects malnutrition when it is already advanced. Rapid rehabilitation in this situation becomes essential to minimize chances of irreversible deleterious effects on neurological system development. This is more likely in our study group considering the fact that the age profile is skewed to the left, indicating that younger children tend to be affected more.

Age and degree of malnutrition

Our study showed no association between age and degree of malnutrition. Considering that in our sample there is a higher prevalence of younger children, the relationship between age and malnutrition appears rather complex. Intuitively one would expect more severity among younger children as supported by a study by Stewart and colleagues⁸. In comparison, a study in Somalia actually showed a lower prevalence among the younger age groups⁹.

Age and degree of weight gain

Our study showed no association between age and the degree of weight gain. This was rather unexpected¹⁰. In India, Sanghvi, Mehta, and Kumar, did a prognostic cohort study on children being rehabilitated for severe acute malnutrition. They found that the younger age group gained weight faster than older children¹¹.

Dietary variety

Our study showed no effect of food variety and weight gain. This was also an unexpected finding, though not uncommon in studies. It is a well-known fact that food variety is an indicator of good nutrition^{12, 13}. Poor food variety is associated with malnutrition and overall decline in health.

The association between health and dietary variety has been the subject of many studies, and some crucial associations have been identified. In Japan, Maier-Noth and colleagues studied the association of dietary diversity, both in weaning foodstuffs fed on the child, and in the lactating mother, in the weaning period (4 to 6 months of age) and development of long-term healthy eating habits. They found a significant positive association in that higher diversity was associated with a greater range of food choices (healthier lifestyle) at later life¹⁴. Apart from under-nutrition, persistent consumption of low- diversity food may lead to hidden hunger, a situation of low levels of vital micronutrients. Micronutrients are components of enzymes, metabolic co-factors immune system and many other physiologic functions. The resultant health problems include obesity, lowered immunity, vulnerability to specific body insults, and overall increase in all-cause mortality^{13, 15}.

A prospective cohort study in Egypt comparing growth of children in two different geopolitical areas found a higher dietary variety in one area, paradoxically with higher malnutrition rates, compared to the other area¹⁶.

Unfortunately food variety is generally low in most households in Botswana, consisting mostly cereal based foods¹², a finding confirmed by this study.

Caregiver Factor

Our study found no association between the type of caregiver and improvement in nutritional status. Other studies have shown that the type of caregiver has a bearing on nutritional status.

As far back as 1979, Turner did a cross sectional study of children in Moshaneng in the Southern part of Botswana and found caretaker factors to influence the nutritional status¹⁷. This finding has been replicated in other studies such as Kadima in 2012 (still in the Southern Botswana)¹⁸ and Ramolefhe and colleagues in the Northern region of the country¹². In the Ramolefhe study, the authors studied the feeding environment of the children at home, and in their paper postulate that children feeding need a closer supervision by the caretaker in order to ensure intake of adequate food, and to inculcate good feeding habits in the child, which will have a long-term effect on the health. Such detailed supervision of young child feeding might be expected to differ between caregivers.

This difference in findings might be explained by the fact that our study subjects differed from those in the other studies in that the children were all malnourished while in the other studies there was a mix of healthy and malnourished children since they were population studies. It might be that the level of care in our subjects was homogenously poor; therefore, caregiver factor might not affect outcomes.

1.5 Conclusion

The study concluded that the weight after 4 months of follow up was significantly higher as compared to the initial stage. However, the rate is only about 15% of the accepted rate, meaning the program is ineffective in rehabilitating malnourished children.

Contrary to other studies, no correlation was found between age of children, dietary variety and caregiver. This may be explained by the fact that the weight gain, though statistically significant, was too low to show such differentiation.

1.6 Recommendations

Since the products in use are a substitute for the designed products, probably the easiest way is to ensure availability of standard RUTF as it has fewer issues of delivery, and with proven efficacy. Since most of the malnourished children are already severely affected at diagnosis, a review of the screening process needs to be reviewed to make it more effective.

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