DOI: 10.7860/JCDR/2022/55126.16746

Effect of *Moringa oleifera* Leaf Powder Supplementation in Children with Severe Acute Malnutrition in Gwalior District of Central India: A Randomised Controlled Trial

HEMANT YADAV[1], AJAY GAUR[2], SATVIK CHAITANYA BANSAL[3]

ABSTRACT

Introduction: Child malnutrition is a major public health problem with a significant impact on child survival. In order to tackle this it is important to improve the nutritional quality of complementary and supplementary food while making it inexpensive and easily available. *Moringa oleifera* is a commonly grown local plant, with high nutritional and medicinal value, can be used as supplement.

Aim: To assess the effect of *Moringa oleifera* leaf powder supplementation on children with Severe Acute Malnutrition (SAM) during facility-based care and home-based care.

Materials and Methods: This randomised controlled trial was conducted in the Severe Malnutrition Treatment Unit (SMTU) of Kamla Raja Hospital, Madhya Pradesh, India. A total of 100 children in the age group of 7-59 months admitted between November 2019 to October 2020, who fulfilled the World Health Organisation (WHO) recommended criteria for identification of severe acute malnutrition were included in the study. The children were randomised to routine supplementation alone (control group) and routine supplementation with *Moringa* leaf powder (intervention group). The anthropometric data was collected at the time of admission to the SMTU, at the time of discharge and every 15 days post discharge for two months. unpaired t-test, Chi-square test and Fischers-exact were used for statistical analysis.

Results: There was significant weight gain (p=0.012) in the intervention group as compared to the control group. Similarly the number of children with severe wasting were significantly less (p=0.032) in the intervention group at the end of two months follow-up. There was no significant difference in height, Head Circumference (HC), Chest Circumference (CC), Mid Upper Arm Circumference (MUAC), Subcutaneous Fat Assessment (SCFA), complications observed between both the groups and duration of hospital stay.

Conclusion: The use of *Moringa oleifera* leaf powder supplementation resulted in improved weight gain and reduction in severe wasting at the end of two months. It has the potential to link both facility-based and home-based care of malnourished children.

Keywords: Child, Dietary diversification, Severe wasting, Weight gain

INTRODUCTION

Malnutrition significantly impacts the survival of a child and is a major public health problem. It adversely effects the cognitive and physical development of children [1]. Although, the under five mortality has shown a significant improvement over the last few decades, but still there are many countries who are facing high burdens of malnutrition [2]. Every year more than three million children die of malnutrition, of which Low and Middle Income Countries (LMIC) bear the major burden [3]. A recent joint report on childhood malnutrition by the United Nations Children's Fund, WHO, and World bank group suggests that staggering 149 and 45.4 million children under five years of age are stunted and wasted [4].

Further, more than one-third and around half of these stunted and wasted children belong to the South Asian region [5]. The magnitude of child under nutrition in India is one of the highest in the world. According to the latest National Family Health Survey (NFHS) -5, less than 5 years of age around 35.5% are stunted, 32.1% are underweight, 19.3 % are wasted and 7.7% of children are severely wasted [6]. So that there is an urgent need to improve childhood nutrition [7].

This would predominantly include improvement of the nutritional quality (energy density, macronutrients, and micronutrients) of complementary and supplementary food. Further, given the budget constraints in the LMIC, there is a need for food based interventions that are less expensive, prepared with locally available ingredients, consistent with local or cultural food habits, and should consider safe handling [7,8].

Moringa oleifera is commonly grown local plant. Nutritional analyses show that its leaves have nutritional and medicinal values; it is rich in protein with high quantities of vitamin A and significant quantities of vitamin C, calcium, iron, potassium, magnesium, selenium, and zinc. It also contains all the essential amino acids, including two which are arginine and histamine that are especially important for children's health [9,10]. The leaves can be easily dried and ground into powder form for use as a nutritional supplement. Looking at the monetary, availability and nutritional benefit of *moringa oleifera*, it can be considered useful in the nutritional rehabilitation of children with severe acute malnutrition [11-14].

However, the clinical trials on usage of *moringa oleifera* as a nutritional supplement in children with severe acute malnutrition are very limited, with no data from India [11]. Hence, present study was done to assess the impact of *moringa oleifera* leaf powder supplementation on children with Severe Acute malnutrition (SAM) during facility-based care and home-based care.

MATERIALS AND METHODS

This randomised controlled trial was conducted in Severe Malnutrition Treatment Unit (SMTU) of Kamla Raja Hospital, Gajra Raja Medical College, and Gwalior, Madhya Pradesh, India, after getting approval from Institutional Ethics Committee (approval certificate no.-87/IEC-GRMC/2019). The study was conducted over a period of 12 months from November 2019 to October 2020. The SMTU specifically focuses on nutritional rehabilitation of SAM children after their initial stabilisation in paediatric ward or intensive care. Informed consent was taken from the parents before enrolling the children in the study.

Inclusion criteria: All the children in the age group of 7-59 months fulfilling the WHO recommended criteria for identification of SAM - (i) Weight for height/length Z score (WFZ) <-3 Standard Deviation AND/OR; (ii) Mid Upper Arm Circumference (MUAC) <11.5 cm and/or; (iii) Bilateral symmetrical bipedal pitting oedema, were included after initial stabilisation when they were transferred to the SMTU [14]. For the feasibility of follow-up only children belong to Gwalior district were included in this study.

Exclusion criteria: The children with associated congenital/chronic problems like congenital heart disease, cystic fibrosis, malabsorption syndromes such as celiac disease, inflammatory bowel disease, and short bowel syndrome were excluded from the study.

Sample size calculation: The CONSORT guidelines for randomised controlled trials were followed [15]. After considering the prevalence of wasting among under 5 children to be 21% in accordance with National Family Health Survey-4 (NFHS-4), with 90% power, 95% confidence interval and assuming 5% decrease in wasting in the test group compared to the control group with enrollment ratio of 1:1, the sample size was calculated to be 94 participants (47 in each group) [16]. In this study, a total of 100 participants were included with 50 participants in each group.

$$k = \frac{n_2}{n_1} = 1$$

$$n_1 = \frac{\left(\sigma_1^2 + \frac{\sigma_2^2}{K}\right)(z_1 - {}^{\alpha}/_2 + z_1 - \beta)^2}{\Delta^2}$$

$$n_1 = \frac{(1.5^2 + 1.5^2/1)(1.96 + 1.28)^2}{1^2}$$

$$n_1 = 47$$

$$n_2 = K * n_1 = 47$$

Δ=|μ2-μ1|=absolute difference between two means

σ1, σ2=variance of mean 1 and 2

n1=sample size for group 1

n2=sample size for group 2

α=probability of type I error (usually 0.05)

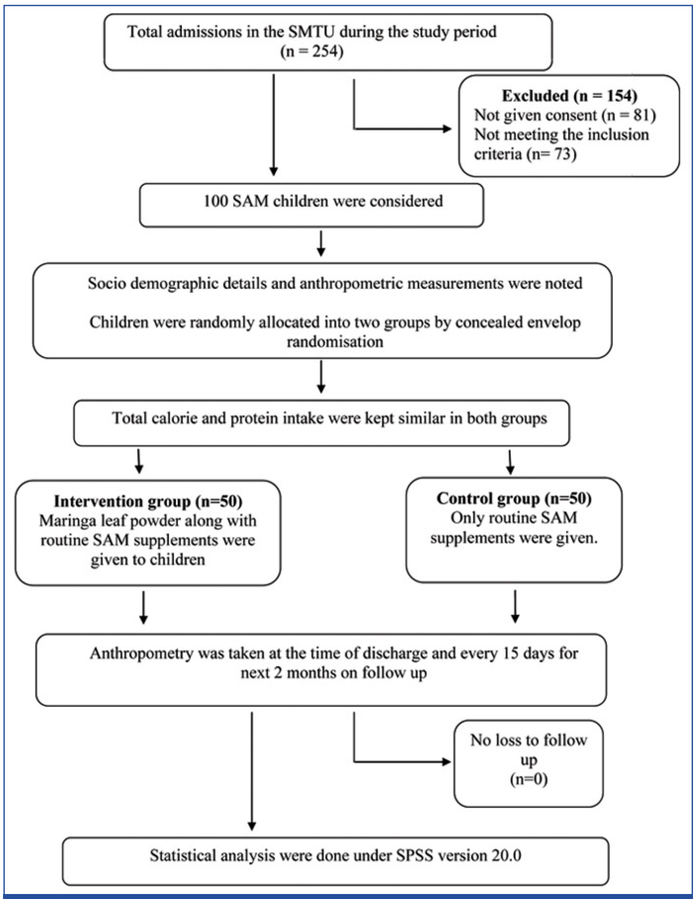
β=probability of type II error (usually 0.1)

z=critical Z value for a given α or β

k=ratio of sample size for group 2 to group 1

Study Procedure

All the children with severe acute malnutrition after admission in SMTU were grouped into intervention group and control group using sealed envelope method. Each child in the Intervention group received *moringa oleifera* leaf powder in the dose of 15 gm twice a day in their diet, in addition to routine SAM supplements and catch up diet that is recommended in the rehabilitative phase of SAM management as per the facility based treatment guidelines issued by the Government of India [17]. The routine supplements included- a multivitamin combination (containing vitamin A, vitamin C, vitamin D, vitamin E and vitamin B12 in twice the recommended daily allowance), folic acid (5 mg on day one, then 1 mg/day), elemental zinc (2 mg/kg/day), copper (0.3 mg/kg/day), iron (3 mg/kg/day), potassium (3-4 meq/kg/ day), magnesium sulphate (0.3 mL/kg IM on day one then followed by oral 0.4-0.6 mmol/kg/daily) and vitamin A (<6 months 50000 IU; 6-12 months or if weight <8 kg 100000 IU; >12 months 200000 IU- single dose). The catch up diet provided calories and protein in the range of 150-220 Kcal/kg/day and 2-4 gm/kg/day respectively [17]. The caregivers were trained during the hospital stay. They were explained that leaf powder could be added common food items such as salads, steamed vegetables, porridges, soups, curry, chapati or rice. Sealed packets of moringa Leaf powder were provided to them, one for each of the 15 days, at the time of discharge and on each follow-up visit. The moringa Leaf powder supplementation was continued with home diet for two months post discharge [Table/Fig-1].



[Table/Fig-1]: CONSORT study flow diagram.

In the control group the child only received the recommended SAM supplements and catch up diet as per the management protocol detailed above. The overall total calories and proteins provided to both the groups were kept in recommended range. The caregivers in both the groups were given dietary advice in adherence to Facility based management guidelines of SAM children [17].

Locally and easily available *moringa oleifera* plant leaves were washed and dried in an airy place out of direct sunlight. Dried leaves were crushed with a mortar and pestle, to make leaf powder which was given to the intervention group [Table/Fig-2].

The data collected was divided into two subgroups

(i) **Socio-demographic details:** Various socio-demographic details were collected at the time of admission to SMTU. These included- age and gender of the children, education and occupation of mother, education and occupation of father, and religion.

(ii) **Anthropometric parameters:** Anthropometric measurements including Weight (W), Height (H), Weight for Height Z score (WFZ), Head Circumference (HC), Chest Circumference (CC), Mid Upper Arm Circumference (MUAC) and Sub-cutaneous Fat Assessment (SCFA) were collected at the time of admission to the SMTU, at the time of discharge and every 15 days post discharge for 2 months [17,18]. The SCFA was done by measuring triceps skin fold thickness with the help of happened callipers [18]. The percentage of children fulfilling the WHO criteria for severe wasting (WHZ <-3 SD) in both the groups were measured at discharge and during each follow-up visit at every15 days for two months [14]. Various complications (indigestion, intolerance, and nausea, stomach upset and vomiting) as well as duration of SMTU stay of participants in both the groups were also compared.

[Table/Fig-2]: Prepared *Moringa oleifera* leaf powder.

STATISTICAL ANALYSIS

Data was entered in Microsoft Word and analysed using Statistical Pacakge of the Social Sciences (SPSS) version 20.0. Frequency distribution and cross tabulation was performed to prepare tables; Microsoft office and PRISM software were used to prepare the graphs. Quantitative data were expressed as mean and standard deviation whereas categorical data were expressed as number and percentage. Mean values were compared using unpaired t-test whereas Chi-square test and fisher-exact test were used to compare percentage and distribution. The p-value of <0.05 was considered as significant.

RESULTS

Socio-demographic characteristics: In this study, it was observed that the baseline socio-demographic characteristics were comparable in both the groups [Table/Fig-3]. The majority of the participants in the intervention group and control group were hindu 44 (88%) versus 42 (84%) followed by muslim 6 (12%) versus 8 (16%). The gender-wise distribution of participants in intervention group and control groups was also similar 26 (52%) females versus 27 (54%) females.

Variables	Intervention group (n=50)	Control group (n=50)	Total (n=100)	p-value
Age (in years)				
7-12 months	29 (58%)	25 (50%)	54 (54%)	0.657
13-24 months	20 (40%)	23 (46%)	43 (43%)	
>24 months	1 (2%)	2 (4%)	3 (3%)	
Sex				
Female	26 (52%)	27 (54%)	53 (52%)	0.841
Male	24 (48%)	23 (46%)	47 (48%)	
Mother's occupation				
Farmer	2 (4%)	1 (2%)	3 (3%)	0.591
Housewife	34 (68%)	29 (58%)	63 (63%)	
Maid	5 (10%)	6 (12%)	11 (11%)	
Daily wage labourer	9 (18%)	14 (28%)	23 (23%)	
Father's occupation				
Driver	6 (12%)	5 (10%)	11 (11%)	0.998
Farmer	7 (14%)	7 (14%)	14 (14%)	
Daily wage labourer	30 (60%)	31 (62%)	61 (61%)	
Painter	4 (8%)	4 (8%)	8 (8%)	
Peon	3 (6%)	3 (6%)	6 (6%)	
Mother's education				
Illiterate	22 (44%)	20 (40%)	42 (42%)	0.685
Middle (5th-8th standard)	26 (52%)	30 (60%)	56 (56%)	
High school (9th-10th standard)	1 (2%)	0	1 (1%)	
Intermediate (11th-12th standard)	1 (2%)	0	1 (1%)	
Father's education				
Illiterate	12 (24%)	11 (22%)	23 (23%)	0.968
Middle (5th-8th standard)	25 (50%)	26 (52%)	51 (51%)	
High school (9th-10th standard)	11 (22%)	13 (28%)	24 (24%)	
Intermediate (11th-12th standard)	2 (4%)	0	2 (2%)	
Religion				
Hindu	44 (88%)	42 (84%)	86 (86%)	0.564
Muslim	6 (12%)	8 (16%)	14 (14%)	

[Table/Fig-3]: Socio-demographic characteristics of the study sample.
Chi-square test for significance with yate's correction was used, p<0.05 was considered statistically significant

The rate of illiteracy was overall high. However, the education status of fathers' was observed to be better than the mothers. In the intervention group 22 (44%) of the mothers and of the fathers 12 (24%) were observed to be illiterate. Similarly, in the control group 20 (40%) of the mothers and 11 (22%) of the fathers had no formal education. Further, most of the mothers were housewives in intervention group and the control group, 34 (68%) versus 29 (58%). Also, the most common occupation amongst fathers was being daily wage labourer's in both the groups 30 (60%) and 31 (62%).

Anthropometric measurements: There was significant weight gain in the intervention group as compared to the control group at the end of two months follow-up (p-value=0.012).There was no significant difference in height, HC, CC, MUAC and SCFA at the end of two months follow-up between the intervention and control group [Table/Fig-4]. Similarly, the number of children with severe wasting were significantly less in the intervention group at the end of two months follow-up (4 in intervention group versus 30 in the control group) [Table/Fig-5].

Variables	Intervention group	Control group	p-value
Mean weight (in kg)			
Admission	6.0172	6.0460	0.905
Discharge	6.1040	6.0515	0.884
15 days follow-up	6.2160	6.0595	0.562
1 month follow-up	6.3580	6.0940	0.263
1.5 months follow-up	6.5100	6.1420	0.119
2 months follow-up	6.7640	6.1740	0.012*
Mean height (in cm)			
Admission	67.0360	67.0360	1.000
Discharge	67.0360	67.0360	1.000
15 days follow-up	67.0820	67.0400	0.971
1 month follow-up	67.1360	67.0480	0.939
1.5 months follow-up	67.1940	67.0580	0.905
2 months follow-up	67.2760	67.0680	0.988
Mean HC (in cm)			
Admission	40.9980	40.9520	0.908
Discharge	40.9980	40.9520	0.908
15 days follow-up	41.0940	40.9520	0.721

1 month follow-up	41.2140	40.9580	0.520
1.5 months follow-up	41.3260	40.9760	0.377
2 months follow-up	41.4760	41.0060	0.238
Mean CC (in cm)			
Admission	42.2780	42.2540	0.968
Discharge	42.3180	42.2940	0.967
15 days follow-up	42.3180	42.3020	0.978
1 month follow-up	42.3180	42.3420	0.967
1.5 months follow-up	42.3340	42.4220	0.880
2 months follow-up	42.3500	42.4620	0.848
Mean MUAC (in cm)			
Admission	11.5020	11.4920	0.976
Discharge	11.7280	11.5920	0.674
15 days follow-up	11.7920	11.5920	0.537
1 month follow-up	11.8880	11.5920	0.360
1.5 months follow-up	11.9760	11.5960	0.240
2 months follow-up	12.0680	11.6020	0.149
Mean SCFA (in mm)			
Admission	29.2460	29.2180	0.959
Discharge	29.4700	29.2200	0.640
15 days follow-up	29.5620	29.2180	0.529
1 month follow-up	29.7240	29.2180	0.371
1.5 months follow-up	29.8160	29.2180	0.290
2 months follow-up	29.8600	29.2180	0.258

[Table/Fig-4]: Association of various anthropometric measurements.
W: Weight; HC: Head circumference; CC: Chest circumference; MUAC: Mid upper arm circumference; SCFA: Sub-cutaneous fat assessment
Unpaired t-test was applied for statistical significance. *p-value <0.05- Statistically significant

Parameters	Group	WHZ (<-3 SD)	p-value
Admission	Intervention	50	1.000
	Control	50	
Discharge	Intervention	50	1.000
	Control	50	
15 days	Intervention	50	1.000
	Control	50	
1 month	Intervention	37	0.921
	Control	50	
1.5 months	Intervention	15	0.905
	Control	50	
2 months	Intervention	4	0.032 *
	Control	30	

[Table/Fig-5]: Frequency of severe wasting between Intervention group and control group.
WHZ: Weight for height Z score; SD: Standard deviation
Chi-square test was applied for statistical significance. *p-value <0.05- statistically significant

In this study, there was no significant difference in complications observed between both the groups [Table/Fig-6]. In both the intervention group and control group most of the children were discharged under 10 days from SMTU (44 vs 46). There was no significant difference in the duration of SMTU stay (p=0.874) in both the groups [Table/Fig-7].

DISCUSSION

In this study, the effectiveness and feasibility of using a locally available food source-*Moringa oliefera* leaf powder was assessed in management of malnutrition. Significant weight gain was observed at the end of two months follow-up.

In the current scenario, it is unlikely that the global SDG (Sustainable Developmental Goals) targets for 2030 will be met, with insufficient

	Group						
	Intervention group (n=50)		Control group (n=50)		Total (n=100)		
Complications	Count	%	Count	%	Count	%	p-value
Indigestion	1	2.0%	0	0	1	1.0%	0.562
Intolerance	1	2.0%	0	0	1	1.0%	
Nausea	1	2.0%	1	2.0%	2	2.0%	
Stomach upset	1	2.0%	0	0	1	1.0%	
Vomiting	1	2.0%	1	2.0%	2	2.0%	

[Table/Fig-6]: Complications observed in both the groups during the study period.
Fisher exact test was applied for statistical significance. *p-value <0.05- Statistically significant

Duration of stay	Intervention group (n=50)	Control group (n=50)	Total (n=100)	p-value
<10 days	44	46	90	0.874
>=10 days	6	4	10	

[Table/Fig-7]: Duration of SMTU stay of participants in both the groups.
Fisher exact test was applied for statistical significance. *p-value <0.05- Statistically significant
SMTU: Severe malnutrition treatment unit

progress made in improving childhood malnutrition [5,19]. Moreover, the South east Asian region to which India belongs, is the predominant contributor to childhood malnutrition worldwide [5,17]. In order to reduce the burden of malnutrition, there are three main public health strategies, food supplementation, fortification of staple foods, and dietary diversification using local foods [11,20]. The efforts in tackling childhood malnutrition, have taken a dent in the ongoing COVID-19 pandemic scenario, with most of the countries struggling to provide adequate nutritional services to children while simultaneously dealing with the pandemic [5]. A survey has shown that 90% of the countries have reported a drop in nutritional services coverage [5]. Dietary diversification strategies using local, low cost, nutrient dense foods have the potential to meet all micronutrient recommendations and overcome nutrient gaps [11,20]. Therefore, there is an urgent need for more emphasis to be put on investigating local food based sustainable approaches and local resources for improving the nutritional status.

The analysis of socio-demographic details of the study population gives an insight into the problem of childhood malnutrition in the country, from a public health perspective. The major percentage of the participants belonged to the age group of 6-12 months (58%). This is a period of very high growth rate and therefore nutritional deficiencies can become more pronounced [21]. Most of the fathers were daily wage workers and mothers were housewives. This means, that there was no constant source of income in the family of the malnourished child. Poverty has been shown to be a strong determinant of malnutrition with major contributors being inadequate nutritional intake, lack of appropriate medical facilities, poor hygiene and sanitation [22,23].

The education level of the parents was observed to be poor in this study, with around half of mothers and one fourth of fathers being illiterate. An analysis done on data collected during NFHS -4 data also suggests that maternal education level were significantly associated with under nutrition in children [24]. There have also been recent studies from South Asia that have also demonstrated a relation between childhood malnutrition and education status of parents [25-27]. Poor eating habits during infancy and childhood secondary to lack of knowledge of optimal dietary habits and components of a balanced diet amongst parents are the major culprits. It has been well established that maternal education is positively associated with healthier diets in the infants and older children [28].

Moringa oleifera is an example of nutrient source that can be easily grown and used at individual or community level [11,13]. Despite lack of data of clinical trials, there is long history of usage of different parts of *moringa oleifera* by traditional healers for treatment of various acute illnesses such as, respiratory diseases, ear and dental infections, chronic morbidities like skin diseases, hypertension and diabetes, cancer treatment, and as a rich nutritional food source for supplementation [11,29,30].

There have been animal studies showing significant weight gain and improved nutritional status by using *moringa oleifera* leaves [31,32]. However, there are very limited clinical trials testing its efficacy in malnourished children [11]. The literature review by the authors resulted in only two previously published randomised control trials in children. First, a longitudinal study was conducted in malnourished children in Burkina Faso by Zongo U et al., [33]. In this study 110 children in the age group of 6-59 months were randomly assigned to two groups. One group received a 10 gm daily supplementation of moringa leaf powder in addition to the usual diet, whereas the control group did not receive any moringa leaf powder. The average daily weight gain (8.9±4.30 g/kg) which was observed in children with moringa leaf powder supplementation was significantly higher than the control group (5.7±2.72 g/kg) (p-value=0.002).

Another, was a study from Ghana by Boating L et al., in which children in the age group of 8-12 months were randomised into three groups- one group daily received cereal- legume based flour with moringa leaf powder (5 gm), the second group received moringa leaf powder (5 gm) with usual diet and control group received cereal legume based flour without *Moringa* leaf powder [34]. The authors did not report any significant difference in the growth indicators. However, in the Ghana study the amount of *Moringa* leaf powder used for daily supplementation was very less as compared to this study (5 gm versus 30 gm in the present trial). Also, the Ghana trial did not specifically include malnourished children and the supplementation was not supervised.

In this study, significant increase in the mean weight gain in the participants of the intervention group was observed as compared to the control group at the end of two months of follow-up. Similarly, the number of children with severe wasting was found to be significantly reduced in the intervention group. However, there was no significant difference in other anthropometric parameters at the end of two months follow-up - mean height, HC, CC, MUAC, SCFA. Similar to this study, the previous trials did not report any significant increase in the height for age scores with use of Moringa leaf powder supplementation [33,34]. The catch up of linear growth in chronically malnourished is generally limited and therefore may not demonstrate improvement with short term nutritional supplementation [35]. The previous trial by Zongo U et al., also measured MUAC in both the groups [33]. The authors observed significant difference (p<0.001) in both groups with or without *Moringa* supplementation, with a greater difference in the group with *Moringa* supplementation. This could be explained by the fact that MUAC is a sensitive parameter to the change in food intake and there was an improvement in the diet in both the groups regardless of additional *Moringa* supplementation [36]. The authors could not find any previous data on the impact of *Moringa* leaf powder supplementation on CC, HC and SCFA in malnourished children. In this study, there was no significant difference in the *moringa oleifera* supplementation group, but long-term supplementation data is needed to further comment.

The average duration of hospital stay is considered as an indicator of effectiveness of the management of malnourished children. Previously published data has shown *moringa oleifera* supplementation to be associated with shorter hospital stay [33]. In this study, although the duration of stay was shorter in the intervention group, it was not found statistically significant. This difference may be attributed to socio-demographic differences in study population from previous studies or can be reflection of unit specific discharge policies. The authors suggest further trials to fully understand the clinical implications of *Moringa* leaf powder supplementation.

In this study, there were no significant complications or tolerability and acceptability issue with the use of *Moringa* powder. The previous study by Zongo U et al., had also reported good tolerability with no significant increase in digestive disorders, respiratory disorders or skin allergies [33]. They had measured resistance by children to consume *moringa oleifera* supplemented porridge. The number was very small and only limited to first week of supplementation. Further, a recent study in Zambian malnourished children to assess the acceptability and safety of *moringa oleifera* powder supplementation concluded it to be a viable proposition for regular use [37].

Limitation(s)

There are certain limitations of this study. It was a single centre hospital based study. Long-term follow-up of the study participants could not be done; this would have helped in better understanding of the sustained impact of *moringa oleifera* leaf powder supplementation and also on optimal duration of supplementation.

CONCLUSION(S)

The use of *moringa oleifera* leaf powder supplementation significantly increased weight gain in severely malnourished children. It has the potential to be used in both facility-based and home-based care of malnourished children due to its low cost, easy availability and high nutritional value. There is a need for larger multicentric trials with long-term follow-up, that can provide required information for incorporation of *moringa oleifera* leaf powder supplementation in the existing guidelines on management of severe malnutrition.

REFERENCES

[1] Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, et al. Maternal and child under nutrition: Global and regional exposures and health consequences. Lancet. 2008;371(9608):243-60.

[2] UNICEF. The State of the World's Children 2019. Children, Food and Nutrition: Growing Well in a Changing World. Accessed on March 02, 2022. Available from: https://www.unicef.org/media/60811/file/SOWC-2019-Exec-summary.pdf.

[3] Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, De Onis M, et al. Maternal and child under nutrition and overweight in low-income and middle-income countries. Lancet. 2013;382(9890):427-51.

[4] UNICEF-WHO-World Bank Group. Malnutrition in Children-UNICEF DA T A n.d. https://data.unicef. Org/topic/nutrition/malnutrition/. Accessed on May 1, 2021.

[5] FAO, IFAD, UNICEF, WFP and WHO. The State of Food Security and Nutrition in the World 2021. Transforming food systems for food security, improved nutrition and affordable healthy diets for all. Accessed on March 10,2022. Available from: https://www.fao.org/3/cb4474en/cb4474en.pdf.

[6] Mohfw, Govt of India. National family health survey (NFHS-5) 2019-2021. Accessed on March 03, 2022. Available from: http://rchiips.org/nfhs/NFHS-5_FCTS/India.pdf.

[7] Webb P, Danaei G, Masters WA, Rosettie KL, Leech AA, Cohen J, et al; Global Nutrition and Policy Consortium. Modelling the potential cost-effectiveness of food-based programs to reduce malnutrition. Glob Food Sec. 2021;29:100550.

[8] Bruyeron O, Denizeau M, Berger J, Trèche S. Marketing complementary foods and supplements in Burkina Faso, Madagascar, and Vietnam: Lessons learned from the Nutridev program. Food Nutr Bull. 2010;31(2 Suppl):S154-67.

[9] Arora S, Arora S. Nutritional significance and therapeutic potential of Moringa oleifera: The wonder plant. J Food Biochem. 2021;45(10):e13933.

[10] Anwar F, Bhanger MI. Analytical characterization of Moringa oleifera seed oil grown in temperate regions of Pakistan. J Agric Food Chem. 2003;51(12):6558-63.

[11] Thurber MD, Fahey JW. Adoption of Moringa oleifera to combat under-nutrition viewed through the lens of the "Diffusion of innovations" theory. Ecol Food Nutr. 2009;48(3):212-25.

[12] Mushtaq BS, Hussain MB, Omer R, Toor HA, Waheed M, Shariati MA, et al. Moringa Oleifera in malnutrition: A comprehensive review. Curr Drug Discov Technol. 2021;18(2):235-43.

[13] Gopalakrishnan L, Doriya K, Kumar DS. Moringa oleifera: A review on nutritive importance and its medicinal application. Food Sci Hum Wellness. 2016;5(2):49-56.

[14] World Health Organisation. WHO Child Growth Standards and the Identification of Severe Acute Malnutrition in Infants and Children: A Joint Statement by the World Health Organization and the United Nations Children's Fund. 2009. Accessed March 03, 2022. Available from: https://apps.who.int/iris/bitstream/handle/10665/44129/9789241598163_eng.pdf;jsessionid=46FC3C8F27AEB0625586B0507DE0B175?sequence=1/.

[15] Schulz KF, Altman DG, Moher D, for the CONSORT Group. CONSORT 2010 Statement: Updated guidelines for reporting parallel group randomised trials. J Clin Epi. 2010;63(8):834-40.

[16] Mohfw, Govt of India. National Family Health Survey (NFHS 4) 2015-2016. Accessed on February 28, 2022. Available from: http://rchiips.org/nfhs/pdf/NFHS4/India.pdf.

[17] MOHFW, Govt of India. Facility based care of Severe Acute Malnutrition Participant manual 2013. Accessed on February 26, 2022. Available from: https://www.nhm.gov.in/images/pdf/programmes/child-health/IEC-materials/participant-manual_fbcsa-Malnutrition.pdf.

[18] Savanur MS, Ghugre PS. BMI, body fat and waist-to-height ratio of stunted v. non-stunted Indian children: A case-control study. Public Health Nutr. 2016;19(8):1389-96.
[19] Global Nutrition Report. Executive Summary Global Nutrition Report 2021. Accessed on March 10, 2022. Available from: https://globalnutritionreport.org/resources/nutrition-profiles/asia/south-eastern-asia/.
[20] Parlesak A, Geelhoed D, Robertson A. Toward the prevention of childhood undernutrition: Diet diversity strategies using locally produced food can overcome gaps in nutrient supply. Food Nutr Bull. 2014;35(2):191-99.
[21] Matonti L, Blasetti A, Chiarelli F. Nutrition and growth in children. Minerva Pediatr 2020;72(6):462-71.
[22] Krasevec J, An X, Kumapley R, Begin F, Frongillo EA. Diet quality and risk of stunting among infants and young children in low- and middle-income countries. Matern Child Nutr. 2017;13(S2):e12430.
[23] Cumming O, Cairncross S. Can water, sanitation and hygiene help eliminate stunting? Current evidence and policy implications. Matern Child Nutr. 2016;12(Suppl 1):91-05.
[24] Panda BK, Mohanty SK, Nayak I, Shastri VD, Subramanian SV. Malnutrition and poverty in India: Does the use of public distribution system matter? BMC Nutr. 2020;6:41.
[25] Khattak UK, Iqbal SP, Ghazanfar H. The role of parents' literacy in malnutrition of children under the age of five years in a semi-urban community of Pakistan: A case-control study. Cureus. 2017;9(6):e1316.
[26] Bhattacharyya M, Roy S, Sarkar A, Sinha RN, Mallick AK, Bandyopadhyay S. Burden of malnutrition among school-going children in a slum area of Kolkata: A matter of concern. J Family Med Prim Care. 2021;10(8):2940-46.
[27] Hossain MB, Khan MH. Role of parental education in reduction of prevalence of childhood undernutrition in Bangladesh. Public Health Nutr. 2018;21(10):1845-54.
[28] Lioret S, Cameron AJ, McNaughton SA, Crawford D, Spence AC, Hesketh K, et al. Association between maternal education and diet of children at 9 months is partially explained by mothers' diet. Matern Child Nutr. 2015;11(4):936-47.
[29] Anwar F, Latif S, Ashraf M, Gilani AH. Moringa oleifera: A food plant with multiple medicinal uses. Phytother Res. 2007;21(1):17-25.
[30] Fahey JW. Moringa oleifera: A review of the medical evidence for its nutritional therapeutic, and prophylactic properties. Part 1. Trees for Life Journal. 2005;1(5):01-05.
[31] Nambiar VS, Seshadri S. Bioavailability trials of β-carotene from fresh and dehydrated drumstick leaves (Moringa oleifera) in a rat model. Plant Foods Hum Nutr. 2001;56(1):83-95.
[32] Sarwatt SV, Milang'ha MS, Lekule FP, Madalla N. Moringa oleifera and cottonseed cake as supplements for smallholder dairy cows fed Napier grass. Livest Res Rural Dev. 2004;16(6):13-20.
[33] Zongo U, Zoungrana SL, Savadogo A, Traoré AS. Nutritional and clinical rehabilitation of severely malnourished children with moringa oleifera Lam. Leaf powder in Ouagadougou (Burkina Faso). Food Nutr Sci. 2013;4(9):991-97.
[34] Boateng L, Quarpong W, Ohemeng A, Asante M, Steiner Asiedu M. Effect of complementary foods fortified with Moringa oleifera leaf powder on hemoglobin concentration and growth of infants in the Eastern Region of Ghana. Food Sci Nutri. 2019;7(1):302-11.
[35] Martorell R. Overview of long-term nutrition intervention studies in Guatemala, 1968-89. Food Nutr Bull. 1992;14(3):01-08.
[36] Grellety E, Golden MH. Weight-for-height and mid-upper-arm circumference should be used independently to diagnose acute malnutrition: Policy implications. BMC Nutr. 2016;2(1):01-07.
[37] Barichella M, Pezzoli G, Faierman SA, Raspini B, Rimoldi M, Cassani E, et al. Nutritional characterisation of Zambian Moringa oleifera: Acceptability and safety of short-term daily supplementation in a group of malnourished girls. Int J Food Sci Nutr. 2019;70(1):107-15.

PARTICULARS OF CONTRIBUTORS:
1. Junior Resident, Department of Paediatrics, Gajra Raja Medical College, Gwalior, Madhya Pradesh, India.
2. Professor and Head, Department of Paediatrics, Gajra Raja Medical College, Gwalior, Madhya Pradesh, India.
3. Assistant Professor, Department of Paediatrics, Gajra Raja Medical College, Gwalior, Madhya Pradesh, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Satvik Chaitanya Bansal,
Assistant Professor, Department of Paediatrics, Gajra Raja Medical College,
Gwalior, Madhya Pradesh, India.
E-mail: drsatvikbansal@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Jan 24, 2022
- Manual Googling: May 27, 2022
- iThenticate Software: Jul 09, 2022 (11%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Jan 22, 2022**
Date of Peer Review: **Feb 24, 2022**
Date of Acceptance: **May 28, 2022**
Date of Publishing: **Aug 01, 2022**